6/7 PHONE NOS. 35 50 55 PCB
8/9 62
18 70
22
30

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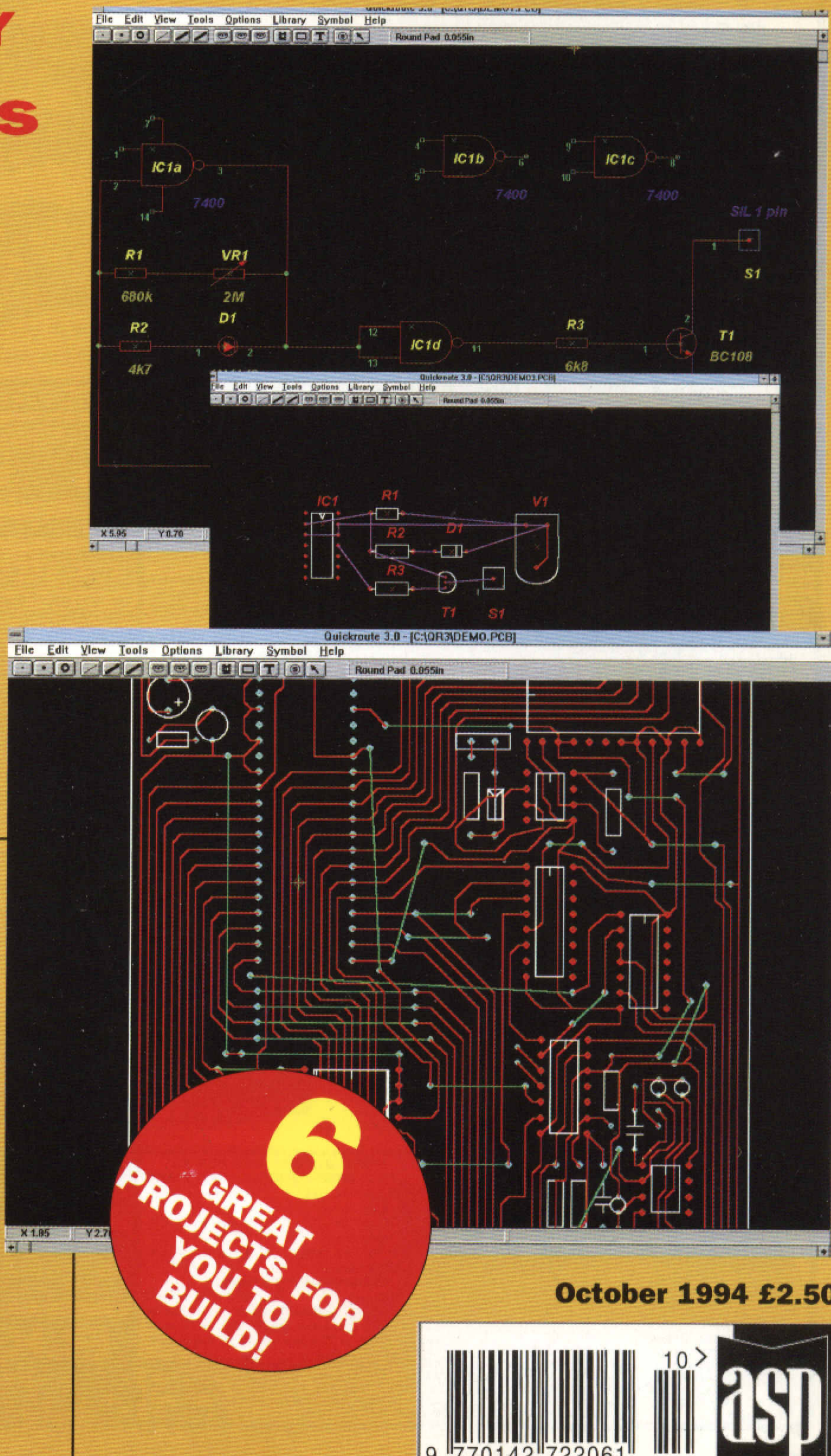

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Contents

P.37 TO P.40 SURVEY FORM
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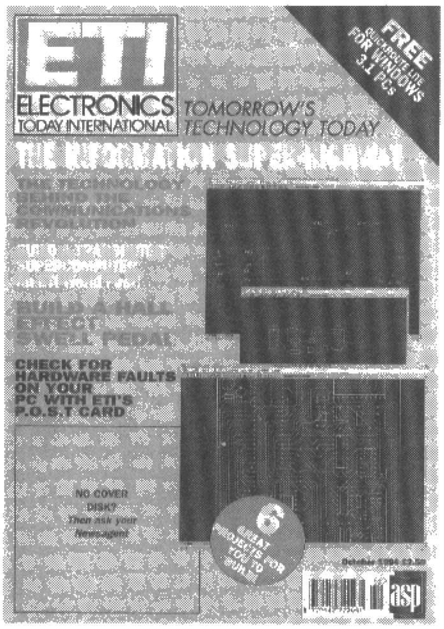
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Volume 23
No.10

Features & Projects

The Information Superhighway
12

Around the world billions are being invested in fibre-optic cable based communications networks, an investment that looks set to generate a whole range of new products and services which utilise its high data transfer capacity. We take a look at some of the technology behind these new products, and some of the applications.

The ETI Cover Disk
18 ~~22~~

This month ETI is giving away a free version of the widely used Quickroute PCB and schematics design programme, which will run on Windows 3.1 based PCs. We take a look at installing and using this useful programme.

Power On Self Test Card
22 ~~30~~

Another ETI special project for PC owners, a plug-in card which can help you to track down faults in a PC even when the machine seems to be completely dead. A very powerful diagnostic aid that no PC owner should be without.

Swell Pedal
30 ~~35~~

Raise the roof with Robert Penfold's latest electronic music project which is based around a Hall Effect device.

PC Clinic
35 ~~18~~

Part 5 of the series which shows readers how to repair, maintain, upgrade, and build circuits for, personal computers. In this issue we look at the main data input devices, the keyboard, and mouse.

The ETI Transputer
44

This month we start the construction of what is probably the world's first practical project to build a single board computer system based around the famous Inmos Transputer chip. Can be used in a wide variety of applications from a graphics engine, to artificial intelligence, it could even be used to build a parallel super computer.

The Rugby Clock
50

Use the ETI Forth SBC project to control a radio capable of receiving the National Physical Laboratory 60Khz time transmission from Rugby

12V Lead-acid Battery Charger
56

Batteries can be very useful as a portable power source, Terry Balbirnie shows how to build a handy constant-voltage charger for standard car batteries.

An Introduction to MIDI
62

In Part 5 of this series Robert Penfold continues his introduction to to the mysteries of MIDI - the now universally accepted standard for communications between electronic musical instruments.

A Touch of Magnetism
66

The third and final part of Keith Garwell's looks at the design and construction of sensitive instrumentation which can detect minute changes in the Earth's magnetic field.

Regulars

News and event diary.- 6

Practically Speaking - 69

PCB Foils- 70

Open Forum- 74

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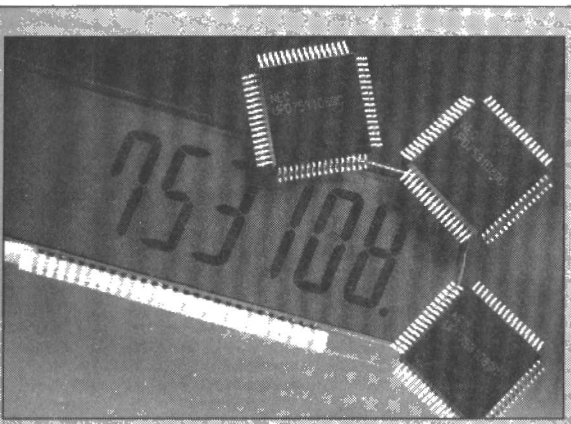
News...



New Low Voltage 4-bit Microcontroller.

NEC has added an LCD option to its new 4-bit 75XL low voltage microcontroller range. The uPD753108 has an integral 24x4 bit LCD driver and the low price and performance enable it to be used in many traditional 8-bit applications, such as automotive and industrial controls.

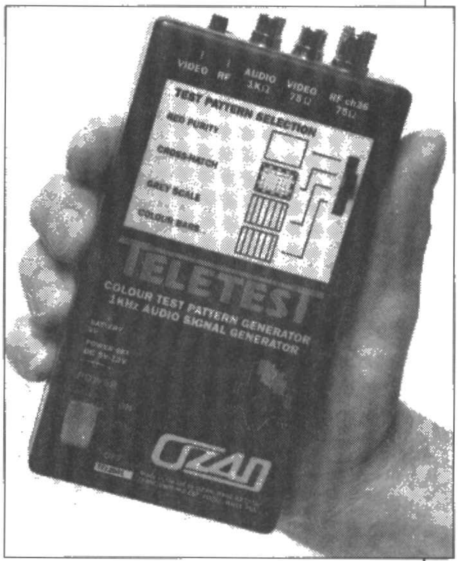
The ultra-low power chip has guarenteed operation from 1.8V to 6.0V, the lower voltage enabling it to be driven from the 'dead' voltage of two lithium cells. This allows the construction of systems that are lighter and more compact than ever before. At 1.8V it has an instruction cycle time of 0.95uS rising to 0.67uS at 4.5V and above.

The uPD753108 has 8Kbytes of ROM memory with 512 nibbles of RAM and there is an OTP version for initial prototyping work. The products are fabricated using 1.0um CMOS, and come in a 64pin QFP package.

For further details contact NEC on 0908 691133

Handheld TV Test Pattern Generator

A new piece of test equipment to help TV engineers has been launched by Ozan, of Poole, Dorset. It is the TELETEST handheld TV test pattern generator. This battery-powered unit can be used to generate a wide range of different test patterns as well as a test audio signal. The patterns produced include standard colour bars, grey scale bars, and crosshatch. Output is via either a RF co-axial socket, a vidio line output from a standard phono socket, and an audio line output also from a phono socket.
All test patterns are synchronised in accordance with CCIR PAL specification: 625 lines, 50Hz field rate fully interlaced, 15,625Hz line frequency with all broadcast specified sync pulses and blanking intervals. For more details contact Ozan on 0202 877270



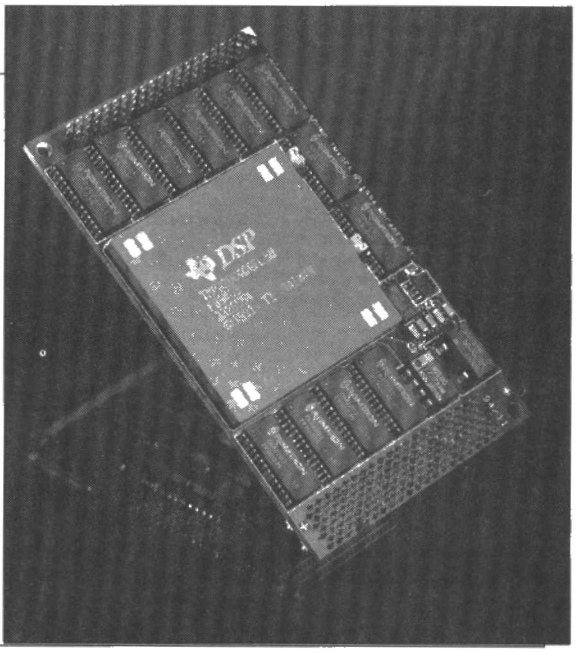
Fast Memory for DSP

Loughborough Sound Images have introduced a new memory module for DSP systems, the MDC40ED. This module packs 12MBytes of near-SRAM performance EDRAM onto a board measuring just 107x64mm.

The EDRAM used combines standard DRAM with SRAM cache in a single package. The combination allows zero wait state performance to be achieved at 50MHz within the same memory page. Available in 8MByte and 12MByte variants, the module is designed so that 35 ICs can be mounted on a single width TIM 40 module.

The combination of high speed and capacity makes the MDC40ED an invaluable element of C40 DSP systems for data intensive applications such as image processing, simulation, radar and sonar.

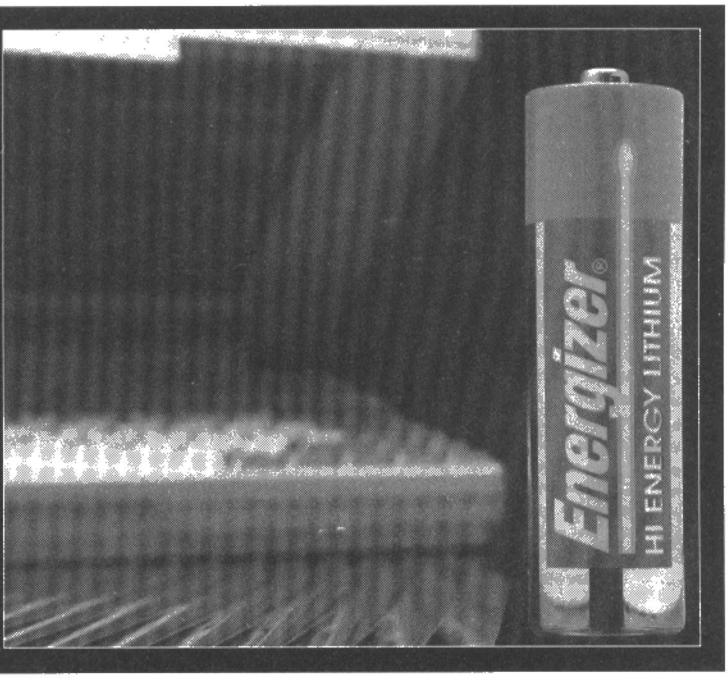
The MDC40ED includes a TMS320C40 global bus connector, on board crystal oscillator, and PEROM containing module identification code for full TIM40 standard compliance. For further details contact LSI on 0509 231843.



World's Longest Lasting Battery.

Everready have launched a new addition to their Energizer range of batteries, the Energizer Hi Energy Lithium, which they claim is the world's longest lasting battery and the first AA sized battery to use advanced lithium technology. It has a life around three times longer than all alkaline equivalents - and in some instances very much more - and is particularly recommended for all high drain appliances. Thus, in a flash gun it will give about 550 flashes compared to 85 from a standard alkaline battery.

Lithium batteries were first developed for professional photographic equipment and have been around for some time, but not until now has this technology been available as an AA battery, the size which accounts for over 60% of all batteries used. A pack of two Hi Energy Lithium batteries has a recomended retail price of £5.99, and they are available from most photographic outlets.



New 16-bit DAC with MPU Interface

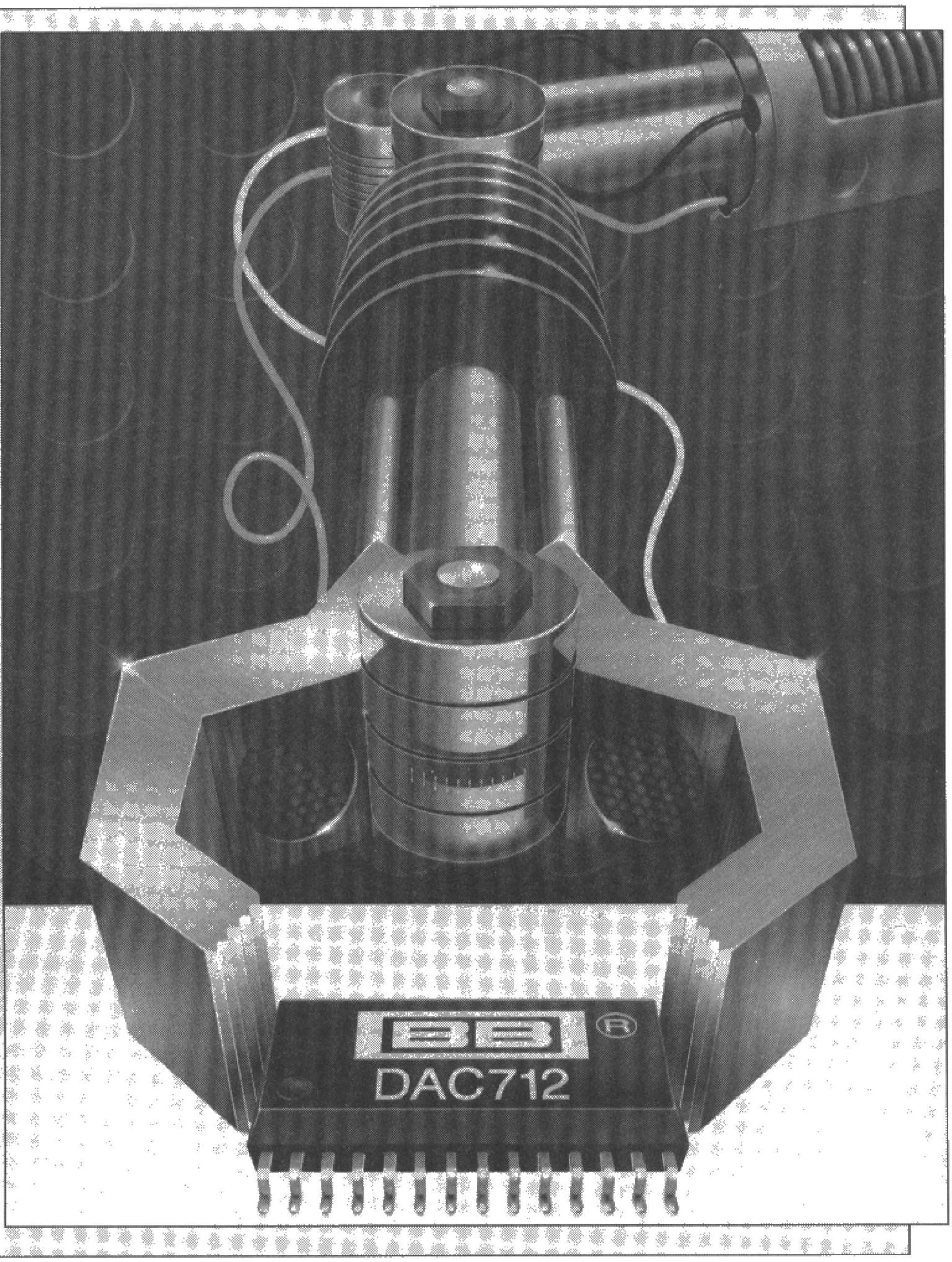
Burr-Brown have just introduced a new 16-bit DAC with a fast 16 bit bus interface, precision temperature compensated reference, and a +/-10V output amplifier. The fast digital interface on the DAC712 is double buffered, allowing simultaneous updating of multiple DACs. Gain and offset adjustments are arranged so that they can be easily trimmed by external dacs as well as by potentiometers.

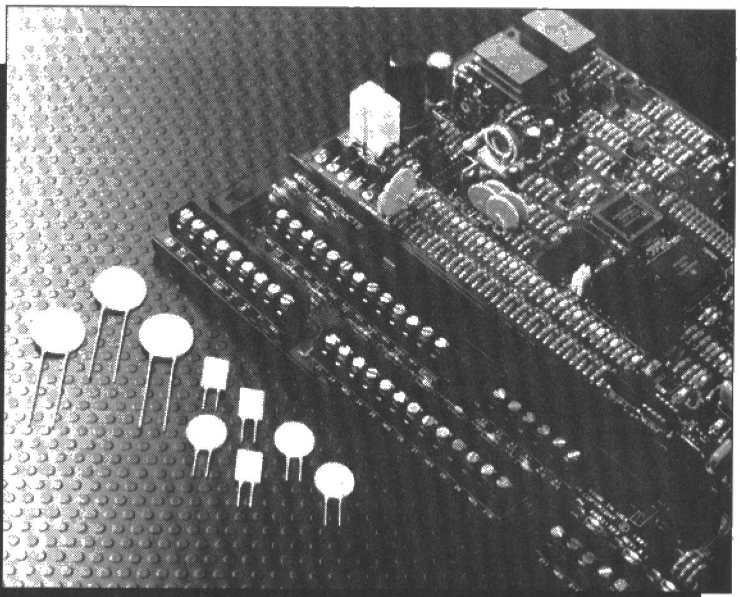
The output amplifier swings +/- 10V with supply rails as low as 11.4V; the output can be set to bipolar zero using the clear input.

Key DC specifications include 14bit linearity, 14bit monotonocity over temperature and 600mW max. power dissipation.

Key AC specifications include 60uS settling time for 20V full scale step, -86dB THD + noise and 87dB SINAD.

For further details about the low cost 28pin DIP packaged DAC contact Burr-Brown on 0923 233837



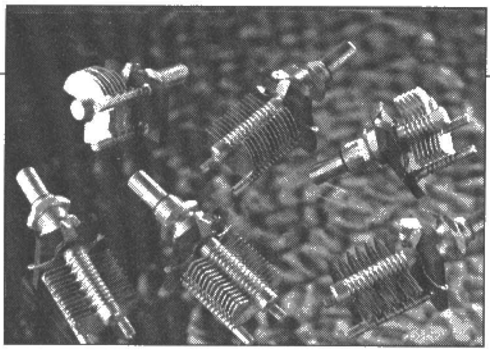


Resettable Circuit Protection Devices.

Raychem are launching a new line of resettable Polyswitch overcurrent protection devices which are smaller and slimmer than comparable components ,yet offer higher current ratings with lower resistance. The Polyswitch RUE family offer designers a reliable testable and resettable circuit protection for a variety of general electronics applications, from fire and security systems to computers.

The devices are radial-leaded, encapsulated positive temperature coefficient (PTC) resistors. Unlike fuses, which must be replaced when blown, the Polyswitch RUE device automatically resets once the fault current is removed. This can result in eliminating warranty costs associated with blowing fuses. Compared to ceramic PTCs, the polymer-based Polyswitch devices trip faster, offer lower resistance under normal current conditions, and come in smaller slimmer packages.

Current ratings are available ranging from .9A to 9A, with minimum trip currents ranging from 1.8A to 18A, with resistance rating as low as .02ohm, maximum voltage rating is 30V. For more information contact Raychem on 0793 528171



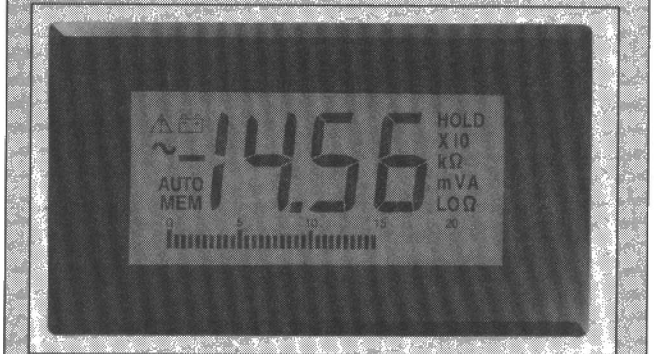
Economy Trimmers

Variable capacitor specialists Jackson Brothers of Croydon have just launched a new range of low-cost air spaced trimmer capacitors. The C824 series are designed to reduce costs without compromising performance in amateur radio and professional applications which do not involve high RF power levels.

The C824 trimmers which are typically less than half the price of comparable components, are available with maximum capacities from 10pF to 100pF. The minimum capacity for all types is 5pF, and all components in the range have a maximum working voltage of 350V DC. The units are constructed around a low-loss composition front panel, and feature aluminium rotor and stator vanes. For further information contact Jackson Brothers on 081 681 2754.

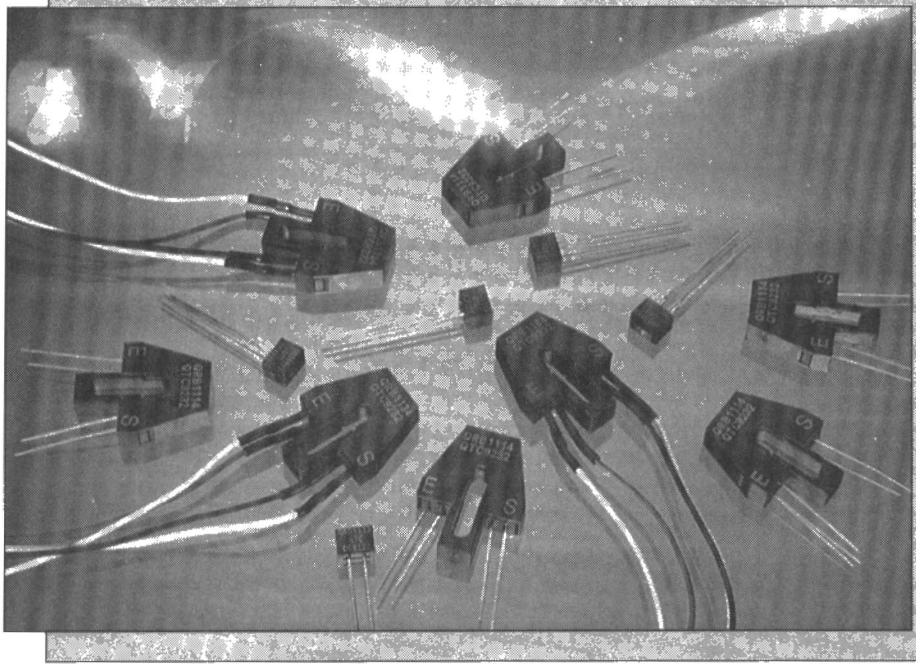
Bargraph DMM

Lascar Electronics of Salisbury, Wiltshire, have just launched a large digit bargraph multimeter, the DMM977. This has a 3 1/2 digit display which can be clearly seen up to 10metres away, even in low light levels, by using the LED backlighting. Connection is by an IDC type connector, suiting low or high volume applications. A robust, low profile mounting bezel is also supplied. Standard features include auto polarity, bar graph, range and display hold. The very low current consumption of the DMM977 results in long battery life, and makes it especially suitable for portable applications. For more details contact Lascar on 0794 884567.



Nickel-metal Hydride Battery.

General Motors Corp has joined Ovonic Battery Co of Troy, Michigan, to develop, manufacture, and commercialise a nickel-metalhydride battery for electric vehicles.Unlike lead acid and nickel-cadmium batteries, currently the most advanced EV battery designs, the proprietary nickel-metal-hydride design is equipped with a negative electrode made up of a mixture of several materials.According to Ovonic, the composite structure consists of varying quantities of vanadium, nickel, titanium, zirconium, chromium, cobalt, manganese, aluminium, and iron. This type of electrode is highly resistant to the fatigue generated by the continuous charge and discharge cycles that occur within an operating battery. the battery is designed to operate for more than 120,000 miles before replacement. In addition to its long life span, the design displays high energy and high power densities, among other high performance features.



Compact Reflective Switches.

Quality Technologies Corporation have developed a range of reliable, solid state, reflective optical switches which are ideal for high speed applications, and other non-contact sensing requirements where the need to sense an object moving in physically cramped areas is only possible in reflective mode.

These highly sensitive switches consist of an infra-red-emitting diode and an NPN silicon phototransistor, mounted side by side on a converging optical axis, and encapsulated in a black plastic housing. For more information contact Quality Technologies on 0296 394499.

Submersible Transducers

RDP Electrosenese of Pottstown, Pennsylvania, have developed a submersible SS series transducer for underwater settings such as dam construction, offshore drilling platforms and the control and monitoring of underwater vehicles. It can also be used in land-based nuclear power plants and waste treatment facilities.

The SS series transducers are built of corrosion-resistant 316 stainless steel. All metal parts have been electron welded to prevent water entering the units. They are equipped with a 0.4-in diameter free armature that is mechanically connected to the moving part or structure being measured and travels in a through hole in the centre of the transducer body. This armature facilitates maintenance and helps minimize the problems of marine growth fouling the unit.

Displacement of the part of the structure being measured causes the armature to move to and fro. The electronics within the SS transducer convert that movement into voltage of 4-20 milliamp current that can be displayed as a direct readout on digital conditioners such as RDP's own microprocessor based Cypher.

RDP engineers designed a special electrical connector fitted to the transducer body. When the connection is mated by being screwed into the transducer, water is forced out of the contact area making a watertight seal. The connector can be attached or disconnected while the displacement transducer is submerged. This allows simplified unit maintenance because the transducer itself can be installed or removed without removing bulky cabling.

Transducers have been incorporated on the ploughs that lay cable on the seabed, controlling and monitoring various mechanical positions and angles, tension and digging depths. The devices also monitor changes in dams and drilling platforms, such as cracks and structural integrity and changes during seismic activity.

The transducers are designed to withstand submersion depths to 2300 metres.

Event Diary.

27-29 June	5th Satellite Systems for Mobile Communications & Navigation Conference, Institute of Electrical Engineers. London. Tel: 071 240 1871
4-7 July	HF Radio Systems and Techniques Conference, Institute of Electrical Engineers, University of York. Tel: 071 240 1871
5 July	Talk on propagation. Sudbury and District Radio Amateurs. Tel: 0787 313212.
14 July	Special Event Station in Woodhall School, Sudbury and District Radio Amateurs. Tel: 0787 313212
16 July	Annual Outing. Crystal Palace and District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: 081 699 5732.
19-21 July	6th Electronic Engineering in Oceanography Conference, Institute of Electrical Engineers. Churchill College Cambridge. Tel: 071 240 1871
20-24 July	Electrotech 94. National Exhibition Centre, Birmingham. Tel: 071 240 1871.
13 Nov.	Midland Amateur Radio Society rally at Stockland Green Leisure Centre, Slade Road, Erdington, Birmingham. Doors open at 10am, admission £1. For further details ring 021 422 9787 or 021 443 1189 (evenings only).

If you are organising an event which you would like to have included in this section, please send full details to ETI, Argus House, Boundary Way, Hemel Hempstead, Herts. HP2 7ST, clearly marking your envelope Event Diary.

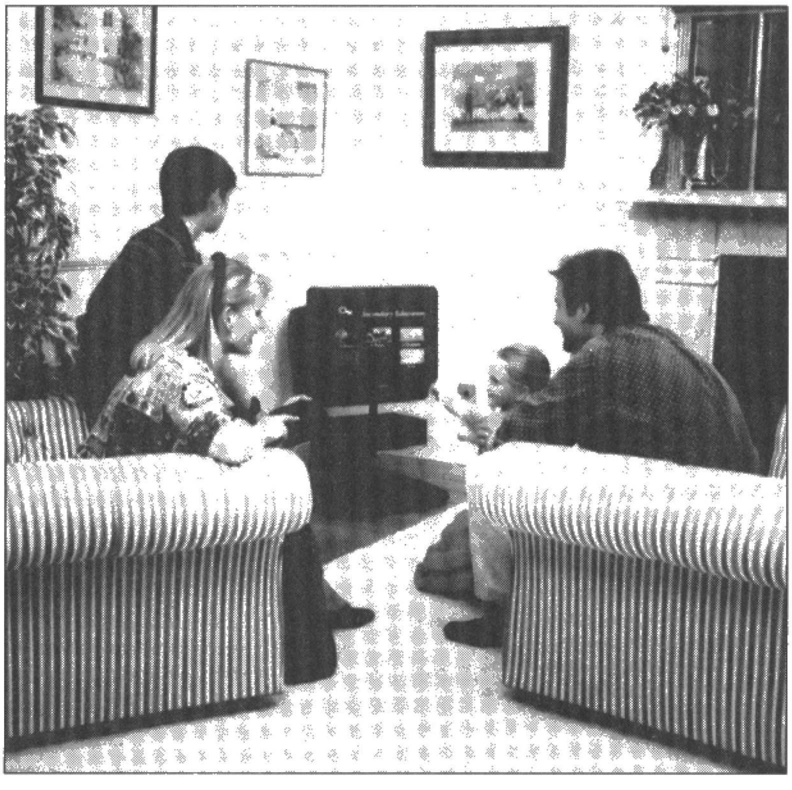
The information superhighway

The installation of very high capacity fibre optic networks heralds a revolution in new telecommunication products and gadgets

Today we all stand on the edge of a technological revolution that looks set to sweep into the lives of all of us. A revolution in communications and information which will affect the way we live, the way we work, and how we spend our leisure time. A truly global revolution that is being fuelled by investments of £billions in fibre-optic cable.

These really enormous sums of money are being invested in fibre-optic networks by telephone and cable TV companies because of the enormous capacity of such networks.- a capacity which can be used to carry almost limitless amounts of information over much longer distances than was possible with copper wires. Indeed, compared to a copper wire, a single strand of optical fibre can, at the moment, carry about 250,000 times as much information.

Initially, about a decade or so ago, phone companies installed fibre-optic cables along main trunk routes because their high capacity enabled them to carry a lot of calls and thus overcome the capacity problems which had started to occur with older copper wire trunk cables. It was cheaper to put in a single very high capacity cable than to have to keep adding new cables to keep up with increasing demand.



Fibre-optic cable networks were also being installed by cable TV companies, a concept that was only really possible using this technology. Using fibre-optic cables, it was possible to deliver a much wider range of TV programmes to the viewer than would have been possible with broadcast systems. Furthermore it is a system which allows the programme providers to directly charge the viewer for programmes watched.

This proliferation of fibre-optic networks led US Vice President Al Gore, a great supporter of technology, to make an analogy between fibre-optic networks and transportation networks. The more lanes you build in a highway the easier it will be for traffic to flow, a flow which will also be made easier if vehicles, speeds, and traffic signs are standardised. We can eliminate transportation bottlenecks by moving from use of highways to superhighways.

But Al Gore took the analogy even further by stating that just as the roads and railways built over the last hundred years have irrevocably changed the developed nations of the world, so these fibre-optic networks will generate equally great changes in the future. Thus was born the concept of the information superhighway, a concept which is firing the imagination of countless companies and individuals around the world and, in so doing, leading to the creation of a wealth of new ideas.

Why the excitement about the superhighway?

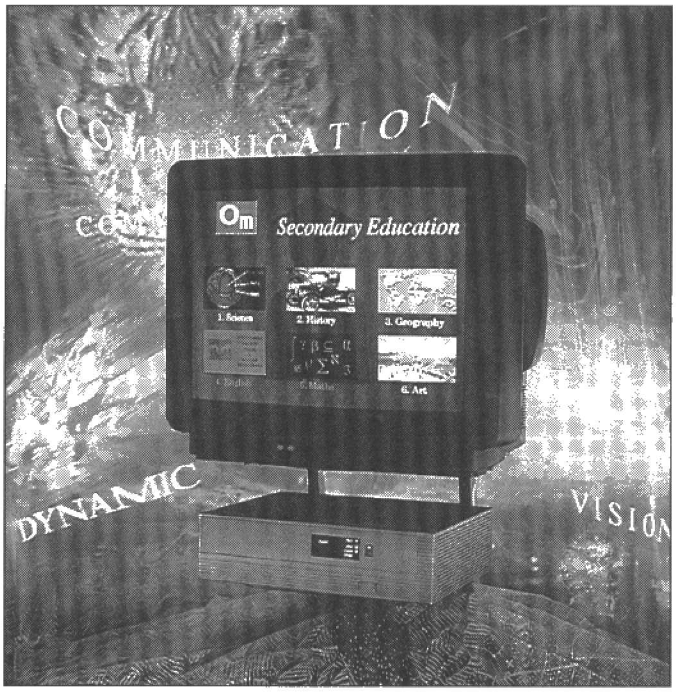
Enormous amounts of money are being invested in the infrastructure of the information superhighway; the Americans are talking about $200billion. Even here in the UK, figures of £30-40billion are being talked about. This is about three or four times the cost of the Channel Tunnel, or a couple of years' worth of UK defence expenditure. However, companies do not invest this kind of money without being fairly certain that they will get a good return on their investment. So where are they looking to make their money?

For a start, a return on this massive investment will not be solely made from conventional voice telephony since the existing network, and hence existing levels of investment, can more than adequately handle that. The answer lies instead in the fibre-optic cable based network's ability to use its enormous data transmission capacity to transfer digitised images - in particular, video images.

The video phone immediately springs to mind when we talk about transferring images across the phone network, but that alone is not a sufficiently strong commercial concept to warrant this type of investment. Instead, the profits should be derived from a whole clutch of video communications based concepts which all rely on a fusion of the interactive nature of phone lines with the impact and information communications capability of the television and the personal computer.

This of course means that the information superhighway will consist of a lot more than simply having fibre-optic cables linking every home and business in the country. Every user will need special terminals to access the desired information that will become available, and information providers will have to have very fast and sophisticated computer systems that are capable of providing that information.

From the user's point of view, therefore, excitement about the concept of the information superhighway is derived from the potentially enormous range of information and entertainment services which will become available. It also comes from the fact that the user will have control over what he receives, unlike existing broadcast television where the program content and schedule is dictated to him by the broadcasting companies.



From the commercial point of view the excitement is generated by the enormous range of new products and services which will arise out of the basic investment in the information superhighway infrastructure. The electronic and personal computer companies are already laying the groundwork for the design of home and office systems, such as the smart set-top box which will sit on top of a conventional TV set and will be used as a central switching station. This box will decode TV signals, handle phone calls, retrieve data, and store user preferences. There will also be special computer interfaces for business applications of the network, computers fitted with video cameras for use in teleworking, and as part of interactive work groups.

The provision of information services using this communications infrastructure will also become very big business and will doubtless lead to an enormous expansion in information providers and program makers - information and programmes which will be charged for by the screenfull or by the minute as well as services which will allow expansion of existing retail and financial operations.

Video and audio on demand

Probably the most talked about service on the information superhighway will be the provision of video and audio on demand. In its simplest form this is an extension of the pay as you view service offered by many cable TV companies. Whereas these services offer particular films at particular hours, in much the same way as a cinema, the video on demand system will be more like an electronic version of a video library. Such systems will allow the user, for a fee, to view any film or programme which is in the library at any time.

The video on demand system would eventually have tens of thousands of films and videos stored in compressed digital form on a network of super computer based server systems. Anyone connected to the network could browse through this library, and view clips/reviews, before selecting one and viewing it. The compressed image data would be sent from the server to the set-top box of the person requesting it where it would be decompressed and output as a normal TV signal that can be viewed on a conventional TV.

The system will also be able to offer the type of 'time-shifted viewing' of broadcast programmes which most of us to a limited extent have been doing with the aid of a video recorder. However, the system will be much more sophisticated, since the server will probably be able to store every programme which has been broadcast over the previous week or more. So if you are a 'soap' fan you could sit down and watch all of last week's episodes

This may sound like a recipe for turning us all into serious couch potatoes but, just as it may encourage some of us to do more viewing, it will also enable us to be more selective in our viewing. Thus the system could be programmed to detect all programmes covering a specific area of interest; all nature programmes, or all sports programmes, and the user could then view all of them or select samples from the identified list.

In some systems it is proposed to go even further than this. Systems are being designed which will allow parts of programmes to be selected that are of interest, such as particular news stories. These will then be put together to automatically form personalised news programmes. This will enable the news providers to produce a much wider range of stories and it will enable the viewer to be more selective thereby preventing wasted time viewing material that is of little or no interest.

At the moment the majority of video on demand systems are in the experimental stage. BT have a trial system using set-top boxes from Apple at their laboratories in Martelsham Heath, near Ipswich. So far this is just linking the homes of 70 employees, but in September the company plan to extend the trial to 2500 homes in the London borough of Westminster where BT owns a cable TV license. As part of this experiment BT has signed up the BBC, Carlton, LWT, Thames TV and Picture Music International as the main material providers They are also talking to several Hollywood studios as well as computer games company Sega.

This next phase of the trial will be used to prove the technology and the potential demand, as well as showing the many politicians who live and work in Westminster what BT will be able to offer if the government will allow it the freedom to compete with the cable TV companies. For a further discussion of this point read the Open Forum piece in this issue.

The British computer company Acorn have also entered the set-top box market through their subsidiary Online media, and have tied up with Anglia TV, News International (publishers of the Times), Northern Telecom, MAI, Oracle, and Cambridge Cable to set up an experimental video on demand system in Cambridge.

However, the most ambitious scheme so far is being devised by Bell Atlantic in the USA. Using a Philips designed set-top box they will be linking over 250,000 people in Washington DC, North Virginia, and East Maryland. This system will have thousands of films, music videos, and television show repeats on its server systems to give a full Video on Demand, or VOD service. Bell expect to expand the services on offer within the next year or so to cover home shopping and banking, computer games and 'enhanced' live TV coverage.

Interactive home shopping, and banking

Another much talked about application for fibre-optic networks and the set-top box is interactive home shopping. Every year, thousands of millions of pounds are spent buying goods by mail order, goods of all sorts that are sold via catalogues or simply via adverts in magazines and newspapers. However, sales are limited by people's natural wariness about buying something which is unseen, hence the enormous expenditure on colour catalogues by the mail order companies.

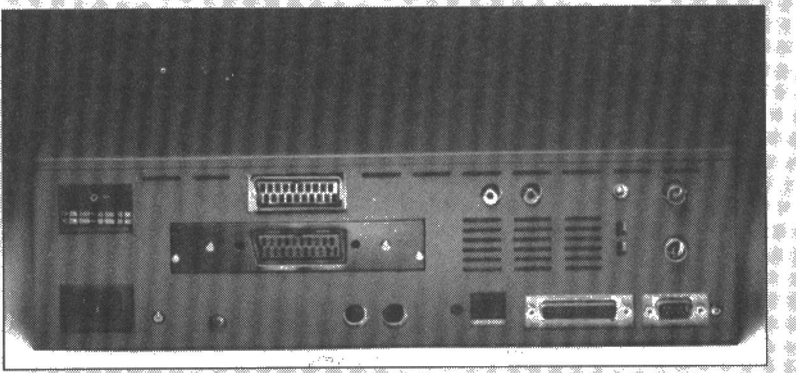
But colour catalogues bring with them another set of problems as far as the mail order companies are concerned. Catalogues are expensive to print and once printed it is impossible to change anything. This means that the pricing and product range of a mail order company tends to be rigidly set. Unlike a high street retailer it is very difficult for them to have a special offer for a few days in order to help move stock, not to mention the fact that it can be very awkward if they run out of stock.

For such companies the idea of having an interactive video

Set Top Box.

One of the key components of the fibre-optic network based interactive information revolution is the so called 'set-top box', or STB, which act as an interface between the domestic TV and the network. Essentially the STB hardware consists of a very powerful personal computer, the design of which has been optimised for handling high quality digitised video. Although all the designs are careful not to actually look like computers, there is no keyboard or monitor for example.This is to overcome an all too common prejudice against computers that is to be found amongst the general public. Thus, no keyboard means no typing, just a fairly conventional hand-held remote control unit.

Apple have been one of the front runners in development of STBs for the interactive TV market, and they have seen STBs as being a good way for them to lever their core computer products into the homes of people who would not necessarily be personal computer buyers. The Apple STB is being used by BT in their trials and basically consists of an LC475 Motorola 040 based system and the high performance graphics card used in the Apple Quadra, with the whole unit selling for about £300. Other major companies in the emerging STB market are Philips and Silicon Graphics.



A British designed STB

It is encouraging to know that British computer manufacturer Acorn have also entered the STB market with a product produced by their subsidiary Online Media. This STB is based around the high performance ARM RISC processor and, in processing terms, is rated at 25MIPS, therefore ideally suited to the demands of interactive multimedia processing. The hardware design is fully static to ensure exceptionally low power consumption and eliminate any need for a cooling fan.

To ensure high sustained performance and reduced bus activity the Acorn STB has a 4KB instruction cache and Write buffer. It also sports a custom memory management unit, with sophisticated page management and support for virtual memory systems. To allow an environment which will fully exploit the array of simultaneous tasks required by interactive multimedia, the high-performance ARM CPU is coupled with a high speed, sub microsecond, multi-level interrupt. The system comes with 2MB of RAM and 2MB of ROM fitted as standard, but these are expandable to allow for future developments.

A separate 32-bit data and address bus allow the high performance architecture to be fully exploited. Allowing real-time decoding of SIF resolution bit streams of 320x240 pixels at 30Hz or 352x288 pixels at 25Hz (operating with a 1.5MBps MPEG data stream). Real-time horizontal interpolation and field duplication ensure high quality moving image reproduction, in either 640x480 pixels at 60Hz (NTSC output format), or 768x576 pixels at 50Hz (PAL output format.

The Acorn STB has a fully programmable VID20 video controller with 8-bit colour DACs for true 16 million colour on screen reproduction, up to 70MHz pixel clock, and interlace support for either PAL(SECAM) or NTSC formats. The sophisticated video features allow features such as picture mixing and effects such as fades, dissolves, scrolls etc for a highly professional looking output.

For the user there is a high-speed, general purpose communications interface designed to accept and maximise the performance of any host interface requirements such as ATM in the home connection. Connection can also be made to a wide range of associated equipment such as SCART in/out, UHF in/out, printer and 16-bit CD quality stereo audio out, as well as the ability to directly interface to a CD-ROM drive. For ease of use, control is via an infra-red handset, and there is a facility for personalised system configuration.

STB software.

Despite the fact that an STB is deliberately designed not to look like a computer it is one, and will be running a special interactive TV server program which will co-ordinate all the processes and allow the user to perform functions such as freeze frame, fast forward, search, etc. as well as handling requests to search for and send information.

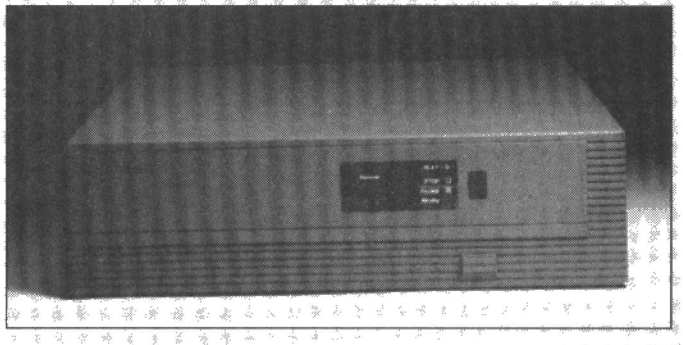
At the moment the two main contenders in the race to produce the world standard STB software are Oracle and Microware's OS/9. The Microware product has in fact been around for nearly sixteen years in various forms, and has been chosen by Philips as the software to run its CD-i system, the basis for its STB.

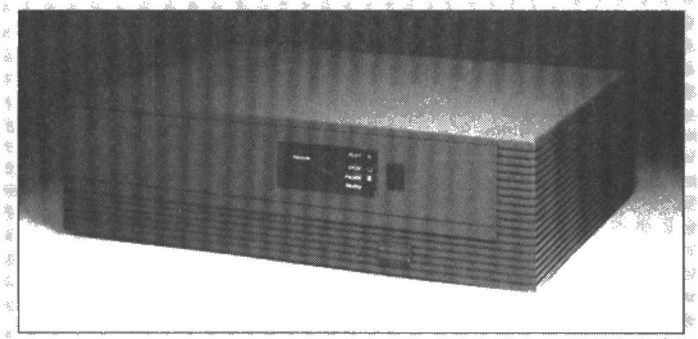
Oracle, the world's third largest software company are in fact producing software for an entire video on demand/STB system, and they are doing so in conjunction with British Telecom. This software is in two parts, that running on the media server, in this case a massively parallel supercomputer, and that running on the STB.

Oracle and BT linked up in 1992 and the first video server based on Oracle software began running on a supercomputer at BT's Martelsham Heath Research Centre at the beginning of April this year. In this system movies are stored in bits at random across a large number of disks, and a massive array of parallel processors are used to re-assemble the digitised video and send it down a phone line to the customer using special video pump software.

The important feature of this software is that it gives a large number of users to simultaneously access a single copy of a film, whilst at the same time allowing each customer to individually start, rewind and pause without affecting any of the other viewers. This technique is in opposition to one being developed by Microsoft who are pumping hundreds of millions of dollars into a system called MIMOSA that will instead rely upon lots of powerful PCs to perform the server function.

Which system wins is still an open question, MIMOSA will not be ready until the middle of next year, meanwhile Bell have chosen Oracle for their Washington DC based 250,000 user video on demand test.





system which goes directly into every household in the country is extremely attractive. Initially, such interactive home shopping systems will probably simply be a video version of a catalogue with the capability of being able to move from any one item to any other item, or look items up in an index. Already there are CD-ROM catalogues which work in this manner. A good example is the new disk from Radiospares.

Within a couple of years developments in software should lead to some interesting refinements. For example, there is no reason why, when buying mail-order clothing, that the system should not be able to show it modelled on a computer generated three dimensional image of the intending purchaser, or at least someone who looks very similar. It will also allow closer links between the manufacturer and the purchaser, again using clothing as an example, it could easily be made to measure, thus giving a better product and also eliminating expensive stock holding.

Furthermore, since the information superhighway will have global links, the suppliers, manufacturers and customers might be anywhere in the world. You could live in London and have your shoes made in Hong Kong, chosen, measured and bought over the global network and delivered by post within the week. The potential implications of this form of global electronic shopping are enormous, and as yet little considered by politicians, businessmen and economists.

Of course, if one can buy things over the information superhighway then one must also be able to pay for them in the same way. In earlier trials of home banking systems security posed a major problem, but with the advent of smart cards such as Nat West's Mondex these problems should be a thing of the past, and the information superhighway can also become a financial superhighway that will give everyone the ability to move their money, at will, anywhere in the world. (More headaches for the politicians!)

Other applications.

Another area of enormous importance will be the use of the superhighway and its associated computer hardware to provide interactive education and training of a quality that could seriously rival conventional methods. Open University type courses could be provided that could be automatically linked in with interactive tutorials and computer generated grading systems. The network could also be used to allow individuals to 'sit-in' on lectures given by some of the finest brains in the world.This means that, in theory, everyone could go to the best university and the best school.

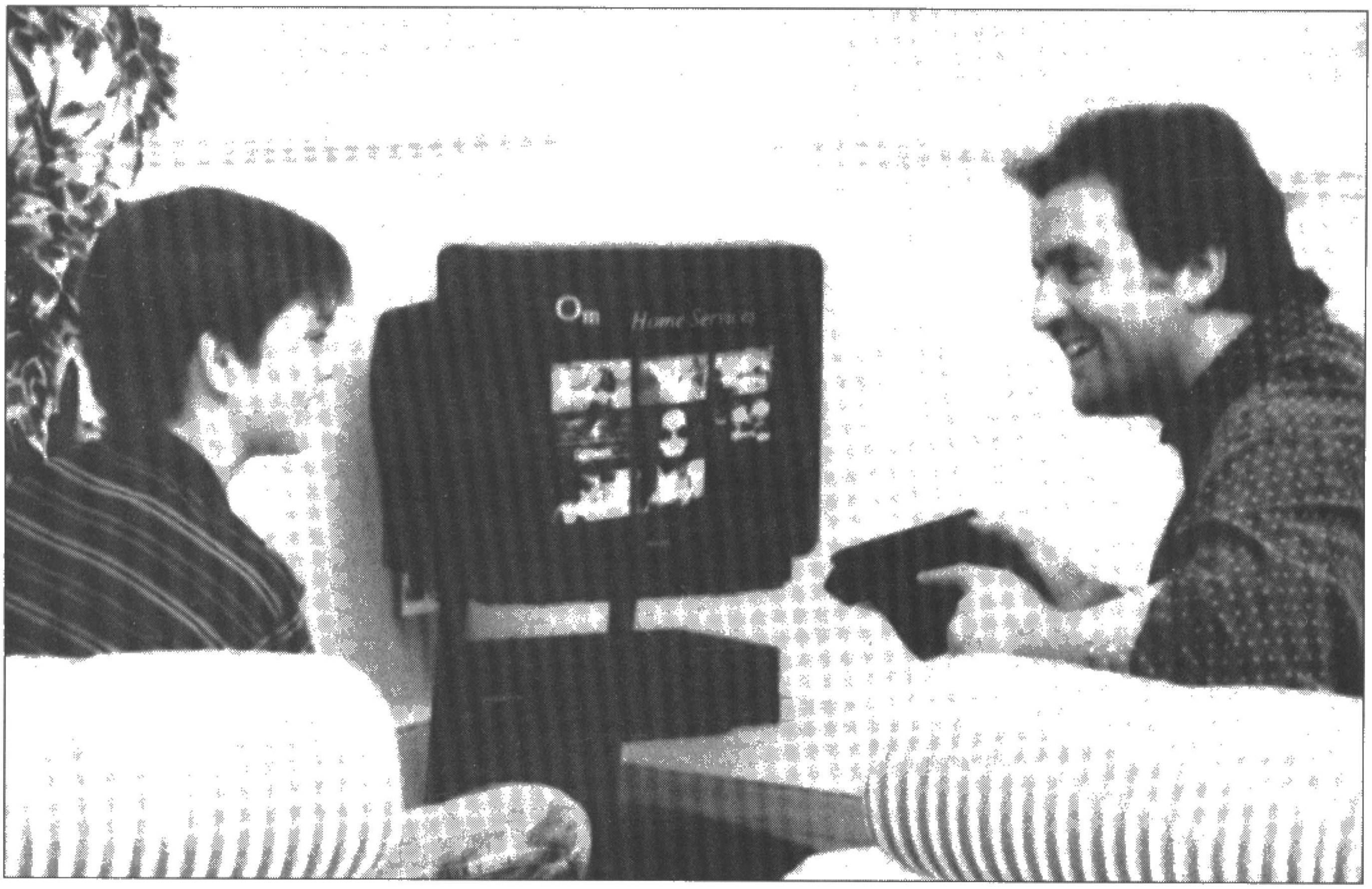
The information superhighway could also change the way in which we work. For a start, it would allow a lot more people to work from home if they so desired. This would have many advantages.It would effectively make the labour force more mobile, it would allow the skills of people like mothers of young children and the physically handicapped to be used, and it would also enable us to reverse the population decline in some of the more remote rural areas of the country.

Into the future on the superhighway

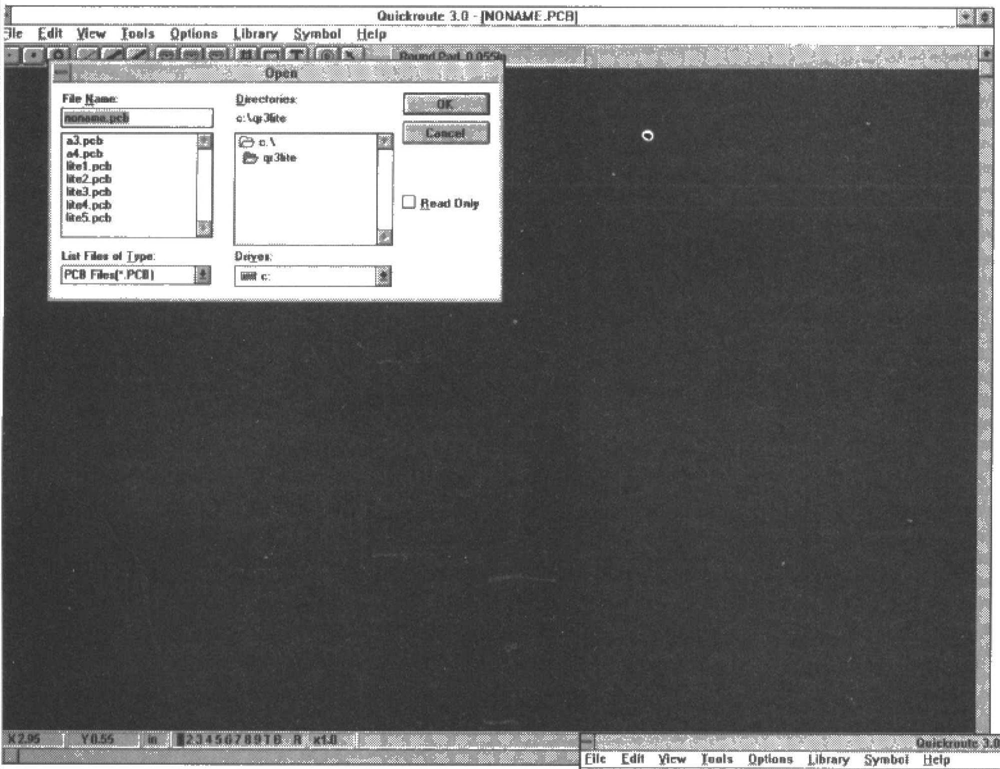
Although the concept of an information superhighway is very much an American one, the infrastructure necessary for such a communications network is already being laid down in all the major developed nations of the world. In the UK, around 7% of the homes in the country are already linked via fibre-optic cable to one or other of the cable TV services, and BT have used fibre-optic cables on the main trunk routes for many years. It is also being laid down on an international basis - most of the new generation of undersea cables are extremely high capacity fibre optic.

However, if the information superhighway is to achieve its aims and provide the world with a communications network that will be the basis for these, and other applications as yet undreamt of, then creating it will require enormous financial resources. Indeed, in the US it has been estimated that building the infrastructure will cost $1000 per household, or $100billion to connect up the entire USA. And if we add onto that the fact that there will be several competing networks, plus all the investment in media servers, STBs, etc. we can easily reach a figure that is four times that much.

It remains to be seen whether investment of this sort can be undertaken by the private sector or whether governments will become involved. It also remains to be seen whether governments will seek to control and regulate the system, some may well see the elimination of national boundaries and controls as a threat that must be countered.



The ETI Cover Disk Quickroute Lite.


Quickroute 3.0 - [NONAME.PCB]
File Edit View Tools Options Library Symbol Help
Round Pad 0.055in
Open
OK
Cancel
☐ Read Only
X2.05 Y0.55 in 1234567890 R x1.0

File Name: noname.pcb
a3.pcb
a4.pcb
lite1.pcb
lite2.pcb
lite3.pcb
lite4.pcb
lite5.pcb
Directories: c:\qr3lite
c:\
qr3lite
List Files of Type: PCB Files(*.PCB)
Drives: c:

On the cover of this issue of ETI we are giving away a copy of Quickroute Lite, a high quality PCB layout and schematics design package which will run on PCs with Windows 3.1.

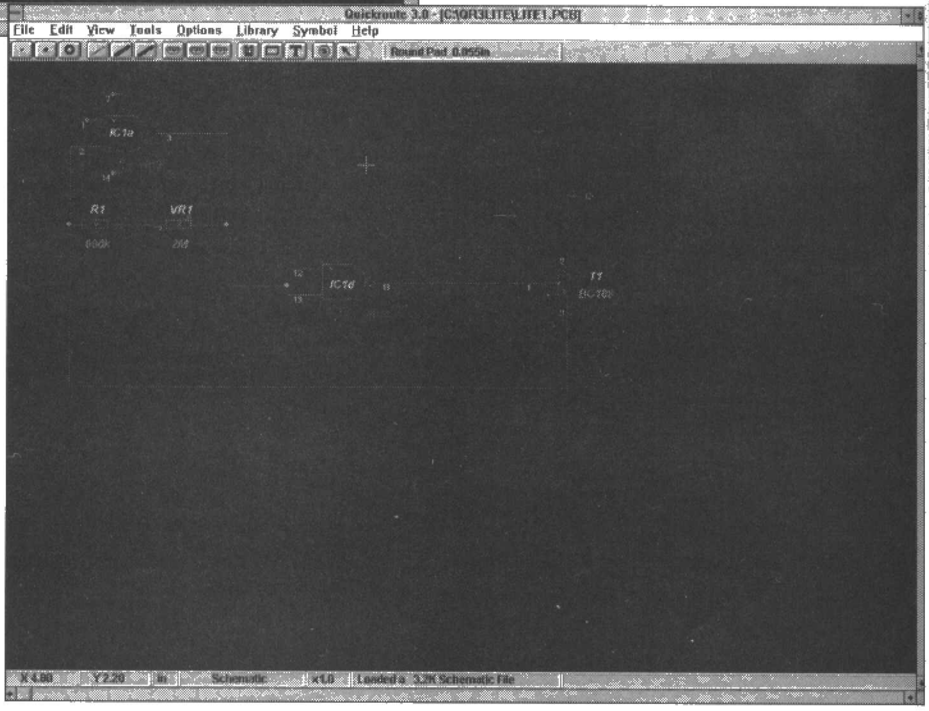
With Quickroute 3.0 Lite, the user can design, edit, save and print PCB's or schematics, and because it is a Windows product, they can make use of a wide range of printers, the product can be used over networks and the designs can be pasted into other applications such as a wordprocessor or DTP document. On the disk included with this month's issue is the main design program, and its associated help files, plus a limited library of symbols which are sufficient to get you up and running. Next month the cover disk will include some additional symbol and component libraries that will allow more sophisticated designs to be produced. There will also be a printable form of the manual and a tutorial.

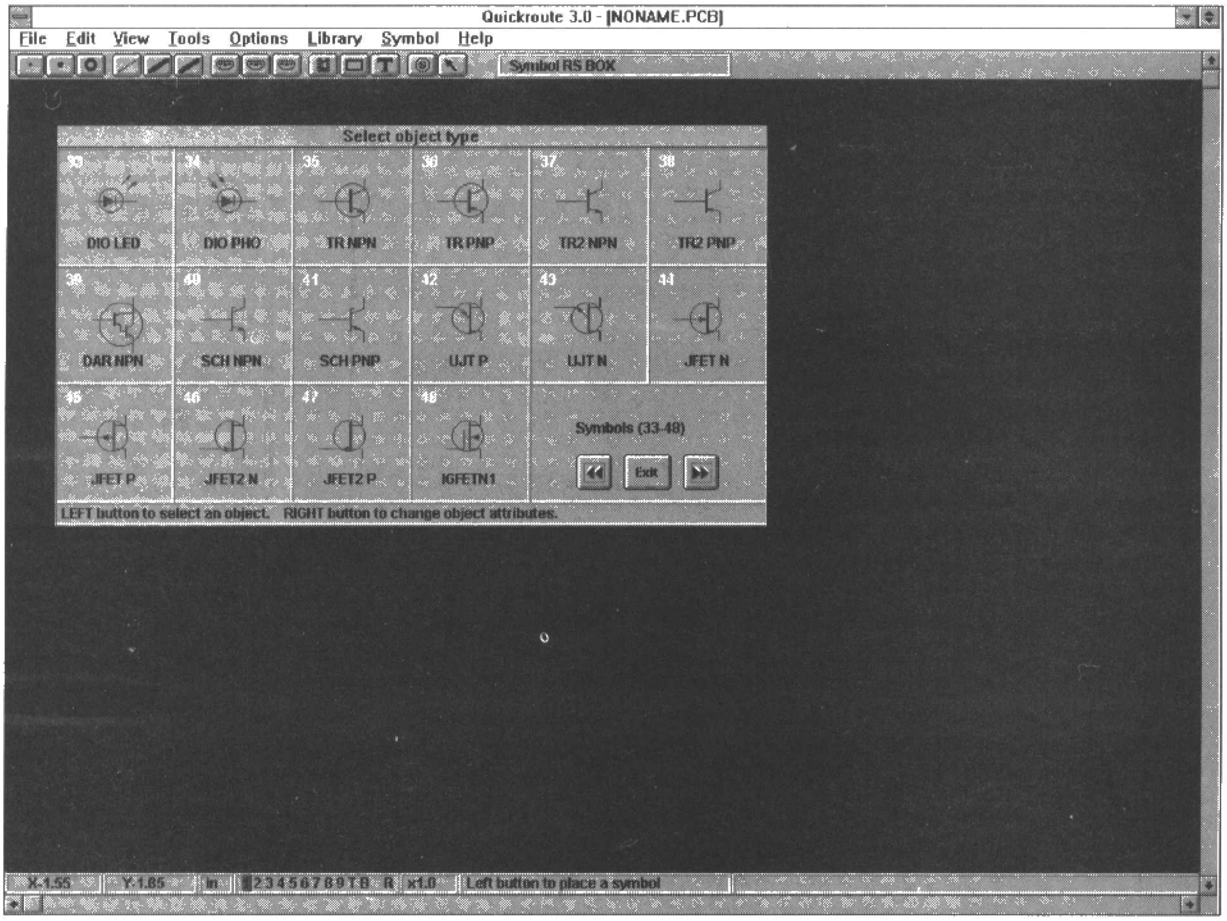
It should be noted of course that this particular version is free, and thus limited in the range of its capabilities compared to the more sophisticated commercial versions of the same program. For example, it does not have the full autorouting facility enabled, and designs are limited to just 500 nodes. However, despite these limitations Quickroute 3.0 Lite can be used to quickly and easily design PCBs with several integrated circuits and associated passives, the sort of design commonly published in ETI, and is thus ideal for use by many hobbyists, as well as schools and training establishments as well as providing a good introduction to the use of such programmes.

Installing Quickroute 3.0 Lite

Quickroute 3.0 Lite is a powerful programme and requires a system with 4Mbytes of memory, a mouse and Windows 3.1. The user should also have around 3-5Mbytes of free hard disk space. A numerical co-processor is also very useful, but not essential. The designers of Quickroute normally recommend that users have a 25MHz 386 based computer or better, although it is likely that the programme will work on machines below this specification.

Since this is a Windows based programme installation is done by first putting the ETI cover disk into the disk drive, then entering Windows File Manager. This can be used to first check


Quickroute 3.0 - [C:\QR3LITE\LITE1.PCB]
File Edit View Tools Options Library Symbol Help
Round Pad 0.055in
IC1a
R1
VR1
IC1d
T1
X 4.00 Y 2.20 in Schematic x1.0 Loaded a 3.2K Schematic File



LEFT button to select an object. RIGHT button to change object attributes.

Left button to place a symbol

that there is data on the disk (an extremely small percentage of cover disks do get damaged, if you are one of the unfortunate ones then just return the disk to ETI editorial offices and we will replace it). If the disk is OK then select INSTALL.EXE and RUN it.

The rest of the installation procedure is virtually automatic, and it will creat a Quickroute Program Group in your Program Manager

Getting started.

To run Quickroute simply double click on the Quickroute Program Group to open the window and then double click on the QR3 icon. Quickroute will then execute displaying a sign on banner and copyright notice, there is no need to enter anything here since this version is specially created for ETI readers.

The mouse cursor, which is normally a small arrow or pointer, changes to a small cross as the mouse moves into the Quickroute window, this can be seen in Fig.2. One can also see from this screen display that at the top of this window is a menu bar, beneath that a button bar, and at the bottom of the screen there is a status bar; scroll bars are to the right and bottom of the main design area.

The first thing to be able to do is load one of the sample files that are included with the program. To do load a design simply click on the FILE command on the menu bar and select OPEN. This will display a dialog box such as that shown in Fig.1. listing the five sample designs and two design grids that are on the disk. To load just select one and click OK. The FILE menu can also be used to save designs to disk, print them out or exit from Quickroute.

The Quickroute Button Bar

Beneath the menu bar are a group of 14 buttons arranged as four groups of three and one of two, these can be clearly seen in Fig.2. Going from left to right, the first three buttons are used to select pads of various sizes (a wide range of different sizes can be assigned to any one button by clicking the right mouse button with the pointer on the desired pad button, this will bring up a menu from which the desired pad can be selected). the second group of three are used to select tracks of varying width.

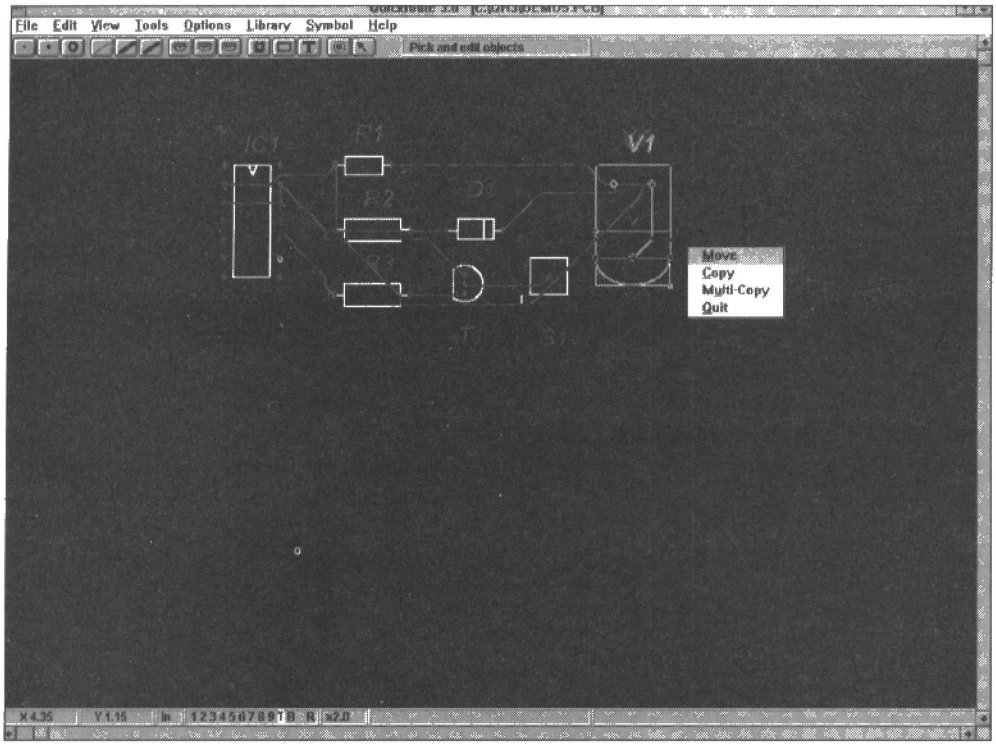
The third group of three buttons are used to select symbols. These symbols are set up with the aid of the LIBRARY menu on the menu bar. Simply select the desired library, there are two on this disk, one for PCB design (CONFIG.SYM) and one for schematic design (SCHEM.SYM), and then use the right mouse button to select from a menu the desired symbol which is to be assigned to each of the three buttons. One of the pages from the Selection Window produced by SCHEM.SYM is shown in Fig.3. and shows a range of component schematics that are available.

The final group of three buttons consist of a DIL pad symbol for use with ICs, a graphics primative button for adding rectangles, circles elipses etc. to the design, and a text button which allows text to be added to any part of the design. With all of these three buttons there is an associated Selection Window which can be accessed using the right mouse button.

Last of all we come to the two buttons at the far right end of the button bar. Button number 13 is used to add pins to the design, these serve no useful purpose on any but the most sophisticated version of Quickroute and are provided for upward compatibility purposes only. Button 14 is an important one to remember because it is the edit button and has to be pushed before one can select, move, cut, or copy any part or all of a design.

Creating a design.

Creating a design, either schematic or PCB, with Quickroute consists simply of selecting objects placing them into the workspace and then linking them with the appropriate lines and



pads. To add a component to the design simply click on one of the component buttons using the left mouse button (make sure that the correct library has been accessed first). To change the component click with the right mouse button and select the desired schematic from the Selection Window (such as the one shown in Fig.3).

When you select a component note that the text shown in the rectangle to the right of the button bar changes to show the object type selected, and that if you selected pads or symbols then the selected object is ghosted with the cursor to enable accurate positioning. Accurate positioning can be aided by making use of one of the design grids that are provided, and to make it easier to see what you are doing make use of the zoom facility in the VIEW menu. You can also pan across the design using the scroll bars (note with some systems you may have part of the old image left on the screen after doing this, to remove it simply go the the VIEW menu and select ALL).

Once objects have been positioned in the workspace they can be linked with tracks. To do this simply select one of the track buttons, and if necessary change the track width using the right mouse button and associated Selection Window. Then place the cursor at the position on the workspace where you wish to start the track, then move the cursor to the end position and click the left mouse button when you are happy with it, or the right mouse button to quit track drawing.

Of course you might want to move objects in order to make joining them together easier, or erase an object or track that was added incorrectly. To do this we need the EDIT function which can be activated by pressing Button 14 on the Button Bar. The cursor will then change to a little arrow which can be used to select tracks and objects. To select a track simply put the cursor on a track node or close to the track and press the left mouse button. To select a pad click on the centre of the pad. For a symbol ,click on a little cross that is drawn within it, the 'hot spot'. Text can be selected by putting the cursor on the first character of the text string and clicking, ICs by putting the cursor on pin 1 and clicking, and primitives by putting the cursor on a corner or edge and clicking.

When an object or track has been selected it will change to the default selected colour, usually a light grey, and solid square boxes will appear at the node points on the object. On tracks these node points will be at the start and finish of the lines and, for other objects, a box will will be drawn around the object with nodes on the corners, this can be seen in Fig.4. If desired one can select a group of objects or even all the objects in a design by holding down the SHIFT key, then holding down CTRL and using the left mouse button to draw a rubber banded rectangle that contains all the objects you wish to select.

Once objects have been selected they can be copied, moved, cut and pasted. To move a selected object, or group of objects, simply put the cursor in the centre of the object or group and keeping the left mouse button pressed drag it to the new position in the display area. When you let go of the mouse button, a pop-up menu will ask whether the object or group is to be moved, copied, or multi-copied. Milti-copying is very useful where one is repeating a group of objects several times, such as the production of data buses.

To cut and paste selected objects you will need to use the pull down EDIT menu. It should be noted that these use the Windows clipboard and is threfore one way to transfer a design from Quickroute to another application such as a word-processor or DTP package.

Going further.

The above is just a quick introduction to using Quickroute and should be sufficient to get you up and running, and allow the creation of some simple designs. There are a lot more features to Quickroute than I have described and next month we will be providing a tutorial program on our cover disk. Don't forget that there is also a comprehensive on-line help facility included with this program which can be used to solve most queries.

Special Reader Offer

For readers who find Quickroute 3.0 Lite useful, but would like to have a more sophisticated and powerful version, the programmes authors are able to offer a 40%discount on Quickroute 3.0 Designer. This will let users edit circuits that are 20 times more complex (10,000 nodes) and also includes full autorouting on 1 or 2 layers. This version normally retails for £99.00 (excluding VAT and P+P) but ETI readers who send a copy of the cover disk from this issue with their order can get it for just £58.00 (excluding VAT and P+P). It should be noted, however, that at this price a printed manual will not be included; instead the full manual text will be available as an on-line help (where it can be printed out).

Orders should be sent to: POWERware, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD. If you have any queries about this or oth versions of Quickroute then Phone or Fax POWERware on 061 449 7101.

Power On Self Test Card for PCs.

Stephen Smith and A.R.Jardine have developed a POST card which allows the user to detect most hardware faults which may appear in a PC, even when the system appears to be completely dead.

On a cold gloomy Sunday afternoon, you settle in front of your trusted PC. Cup of tea in one hand, in the other the latest bloodcurdling offering from IDS software. There you are waiting to bludgeon your first alien, when every computer user's worst nightmare strikes. What are you greeted with - the comforting "C:\ >" prompt, no - nothing. A blank screen stares bleakly out at you. Nothing but a dead computer. But what can you do?

This is where you would love to have a doctor/patient relationship. Just by asking, "Now what is wrong with you today PC?", you get a simple reply to the problem. Unfortunately, computers cannot talk to us about the problem. But the clever PC has found a way to communicate its ailments to you. The PC goes through a series of tests, a sort of daily physical. This sequence of tests is called POST (Power On Self Test). All you have to do is interpret the information this gives you. Not an easy feat. So this is where your POST card steps in to help you out.

What is POST?

POST is a sequence of program routines built into the motherboard's ROM (the BIOS). This tests vital system parts at the time of power-on. The system BIOS commences and oversees the POST. What, when and how the system is tested is BIOS dependant. The POST testing is completed before the PC attempts to load the operating system. This ensures that the system is fully functional before any essential operating system functions are started. This is what is going on in that infuriating

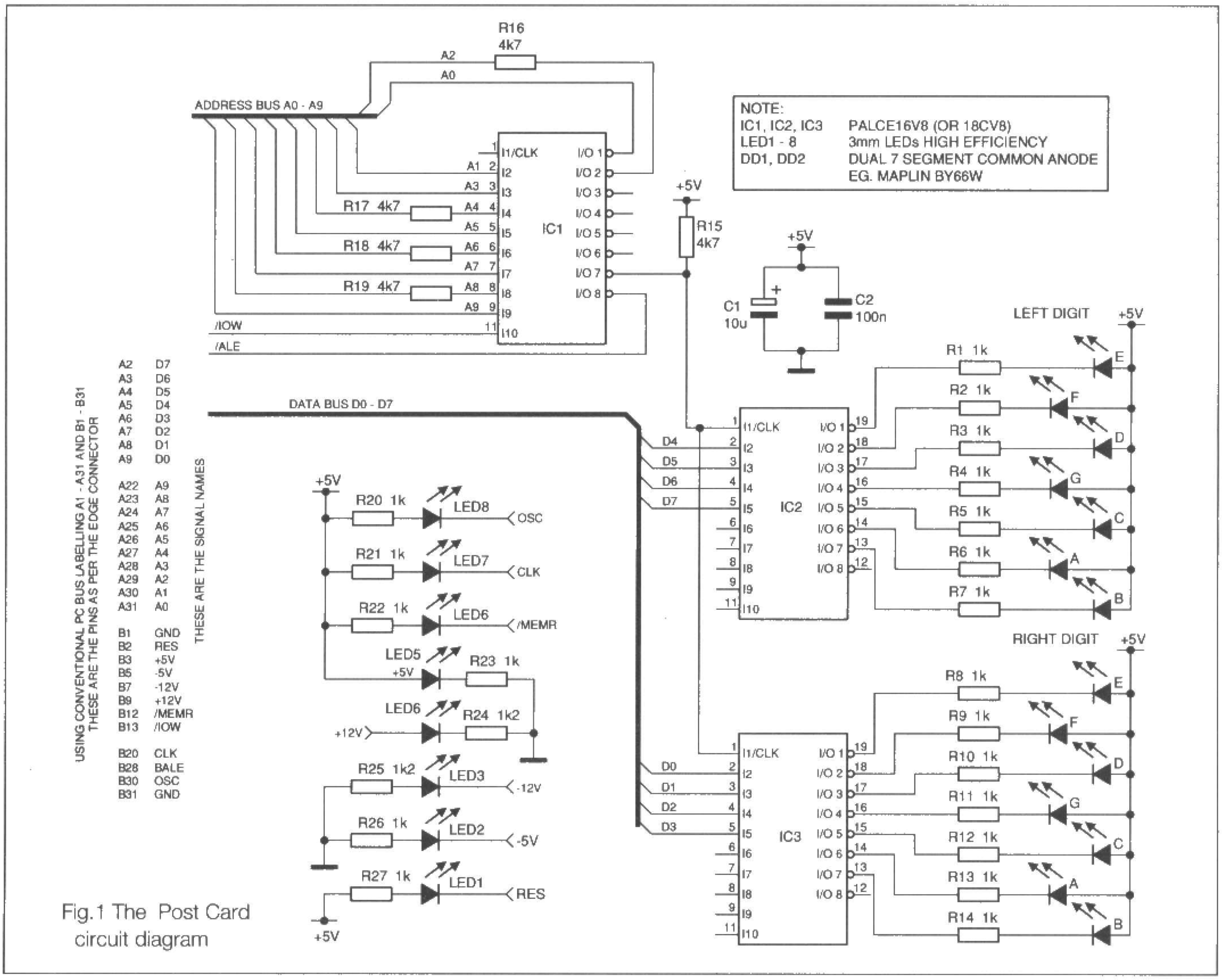


Fig.1 The Post Card circuit diagram

delay when you turn on an IBM-compatible personal computer. POST was developed as a way of testing the PC at all stages of its life. The memory, DMA, interrupt controller etc. on the motherboard can be tested with POST during its manufacture. Such a test requires only a power supply and a POST card like the one described here. Then when the system is assembled, disk drives inserted, display and input/output cards installed, the POST is used again to test the whole system. These tests are the machine's first line of defence against hardware faults, as they are run every time the machine is powered up.

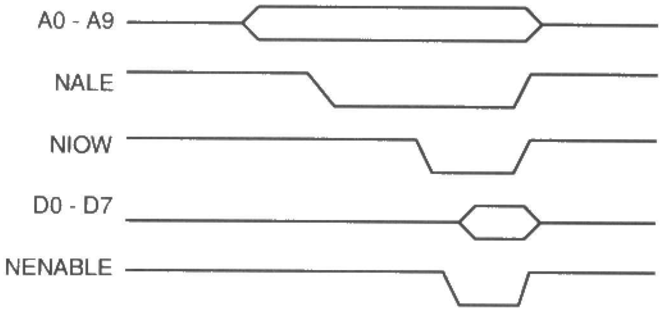
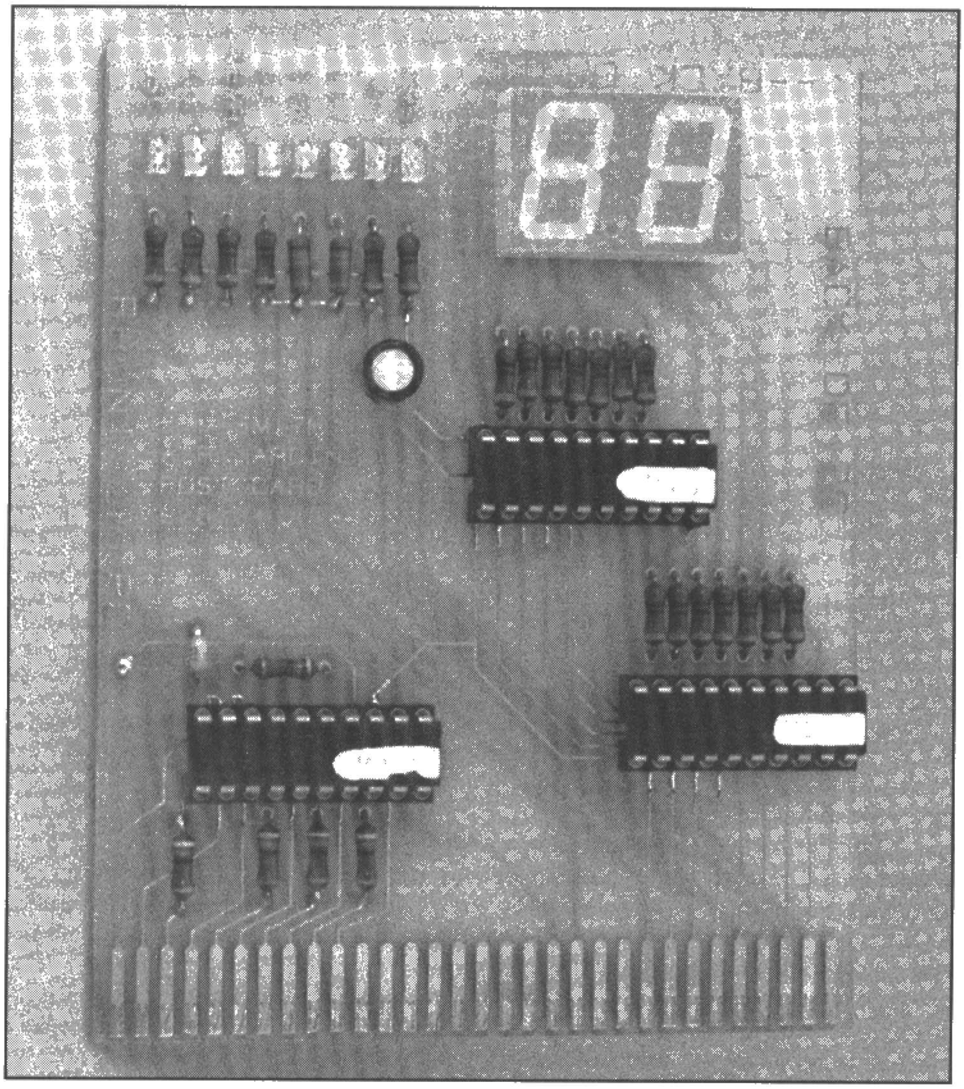


Fig.2 The Bus timeing diagram

The computer automatically starts POST every time it is turned on. These specific tests scrutinise the main elements in the system. (i.e. CPU, ROM, motherboard support circuitry, memory, keyboard, video, hard and floppy drives, etc). Although these tests are brief in comparison with disk-based diagnostic packages, they are vital in error detection. Often, a system experiencing a serious problem is unable to function sufficiently to load the disk-based diagnostic package. POST is able to operate and directs you to the source of the problem, providing a warning or error message as soon as a fault is discovered. Three types of output message are provided:- audio codes, display screen messages and the test codes (POST codes sent to an input/output port address) .



POST audio error codes consist of a sequence of audio beeps, which can simply identify a faulty component. For a normal functioning system, one short beep is emitted when the system passes the POST tests and then goes on to boot the operating system. If a difficulty is encountered during the testing a different series of beeps is signalled. The precise code emitted is BIOS dependent. Next month we will catalogue various audio error codes and associated problem areas.

POST codes are test codes sent to an input/output port address at the start of each test. A special adapter card plugged into a system slot can decode the POST codes, like the one detailed here. These codes pin-point each element tested by POST. During the POST testing, two-digit numeric codes is passed to the adapter's display. If the POST cycle stops unexpectedly, the two-digits displayed on the card indicates where the test has failed, and therefore points an accusing finger at the faulty component. Next month we will catalogue various BIOS POST codes and associated problem areas.

Many commercial cards exist to inform the user of the POST codes. The majority of these display the codes on a pair of seven segment displays, and the user has to then look up their meaning. Some older cards can take over the machine with a special test BIOS, but as all modern BIOSs include POST testing, this capability is mostly redundant. Other cards monitor various bus signals and report their status. One solution to the problem of deciphering the POST code, is to have a computer program to retrieve the meanings of the codes and any suggestions about action to take. This, however, requires a second functional computer and is therefore not practical for the casual user.

The card described here uses a dual seven-segment display to report the status of the POST testing. In addition eight LEDs are used to indicate the status of four bus signals and four power supply lines. This does not guarantee that the supplies

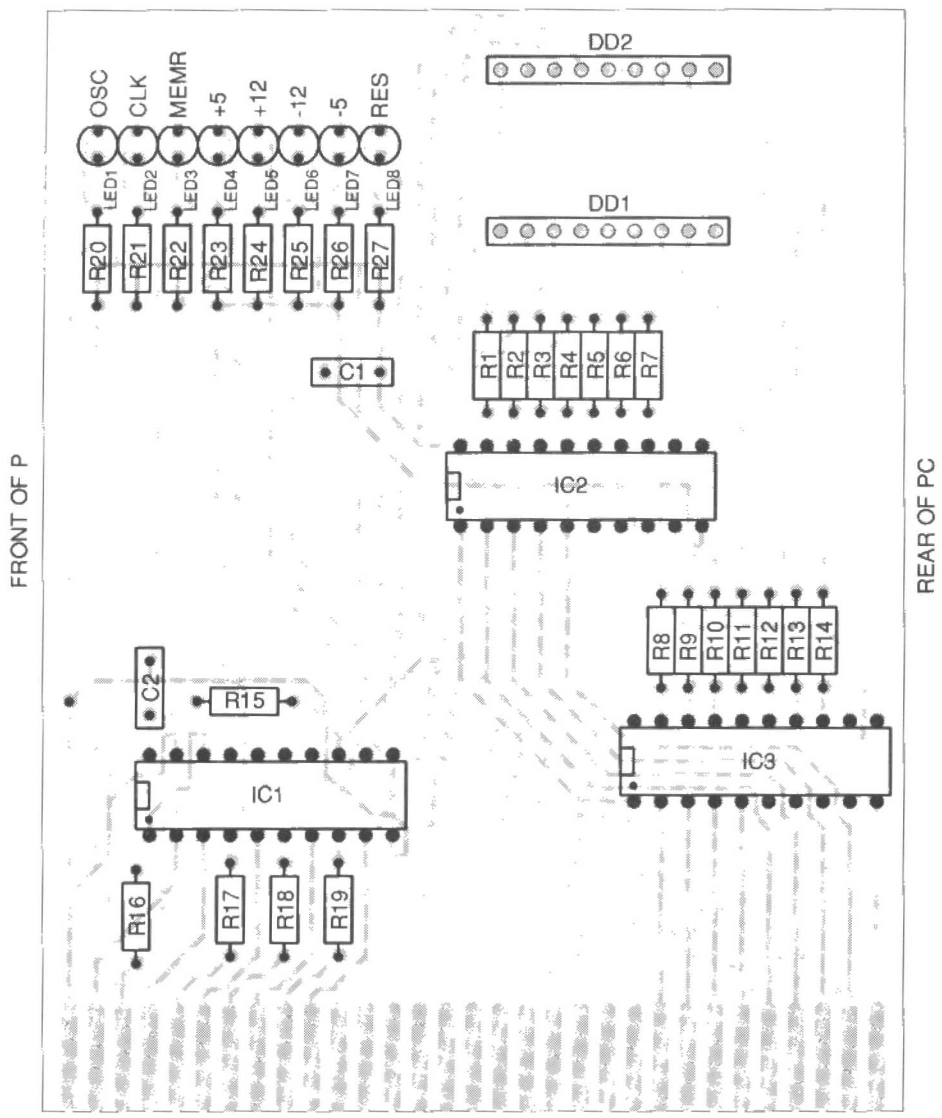


Fig .3 Post Card component overlay

are within tolerance - just that they are present. You have to use a multimeter for that.

The objective behind the development of this card was to produce a cheap card that was easy to use and had a degree of protection. With commercial cards costing at least £150 and with no protection, which would you rather use and risk damaging: a £150 or a £30 card? Add to this the fact that you have full circuit diagrams and information on the cheap card that you made yourself.

Software diagnostics packages require the majority of the system to be functional. (i.e. You need to be able to boot the system and run the software.) POST cards operate before booting so they will diagnose faults that hinder booting. Also as the POST card has its own display, it does not rely upon the functionality of the system's normal monitor display. This means that the POST card can find fault in 'dead PCs'. The POST card is a natural compliment to software diagnostic packages.

Which PCs can use the POST card, I hear you ask. (Strange, the funny noises you hear in the early hours of the morning.) To use the POST card, your system must be an IBM AT or 100% compatible; equipped with an 80286, 80386, 80486 or Pentium microprocessor; with an ISA or EISA bus. Vesa and PCI local bus systems are catered for as they all have ISA expansion slots. Some PC and XT systems with modern BIOS's can also use the POST card. Check with your system's manuals for further details.

There are eight status LEDs on the POST card. If you look carefully at the card, you will note that they are labelled on the board. From left to right, OSC, CLK, MEMR, +5, +12, -12, -5 and RES. If the particular LED is lit, then that element is functional. The status LEDs are an invaluable tool for fault finding. Even if the PC is unable to run POST, the LEDs direct the user to where the problem originates.

OSC: This represents the bus oscillator of 14.318MHz. Informing whether the clock used by the expansion cards is working.

CLK: This is derived from the processor clock and is usually in the range 8 to 12 MHz. Thus indicating a level of functionality of the main clock generator circuitry.

MEMR: Memory read signal on expansion bus. This indicates activity on bus.

+5,+12,-12,-5: These are the power supply lines. The LEDs being lit does not necessarily indicate that they are at the correct voltage.

RES: This represents reset. Indicating the status of the reset line, which is imperative to the operation of the system It is initially off for about half a second then is on during normal operation.

How It Works.

The IBM-AT and clones indicate the POST test currently in progress by sending a byte to the input/output address 80Hex. All the POST card has to do is catch these bytes and give them to you in a form you can understand. Referring to Figure 1. "But why use PALs?" I hear you ask. (The voices, the voices.) The address decoding is in one PAL as opposed to three pieces of descrete logic. Hexadecimal seven segment drivers are not readily available. The only alternative is using intelligent displays that cost about £10 each. Using PALs allows a cheaper and simpler design to be produced.

The three PALs do all the hard work, making your life easy. IC1 does the address decoding, IC2 and IC3 drive a seven segment digit each. The address decoding waits for 80Hex on the ten address lines with logic lows on the two control lines (NALE and NIOW). Figure 2 illustrates this write cycle, (more later). This enable signal latches the decoded hexadecimal digit at the output of the PALs A logic low on the output of a PAL

Listing 1

```
'       PC_TEST.PLD       Address decoding
for the PC test
       circuit.
'                         S.M.Smith 20/7/93


DEVICE 16V8;              '      PAL could use
18CV8

'       Define the following pin out.


'       NC          1  20       VCC
'       A1          2  19       A0
'       A3          3  18       A2
'       A4          4  17       NC
'       A5          5  16       NC
'       A6          6  15       NC
'       A7          7  14       NC
'       A8          8  13       Nlatch  must be
pulled up Tristate
'       A9          9  12       NALE
'       GND      10    11       NIOW

VCC     20  '       POWER SUPPLY.
GND     10

A0       19 '        ADDRESS A0
A1       2     '       A1
A2       18    '       A2
A3       3  '      A3
A4       4  '      A4
A5       5  '      A5
A6       6     '       A6
A7       7  '      A7
A8       8  '      A8
A9       9  '      A9

NALE     1  '        Address Latch Enable (Active
Low)
NIOW     11    '       I/O Write ( Active Low )

NLATCH  13     '       The Output Strobe at 80
hex

START

NLATCH  /= /A0 * /A1 * /A2 * /A3 * /A4 * /A5
*/A6 * A7 * /A8 *
/A9 * /NALE * /NIOW;
End;
```

Listing 2.

```
'       HEX7SEG.PLD      SEVEN SEGMENT DECODING
for the PC test circuit.
'                                       S.M.Smith
4/8/93    reordered outputs 27/5/94


DEVICE  16R8; '       PAL16R8  so could use
16V8 or 18CV8

VCC   20          '       POWER SUPPLY.
GND   10

CLK   1           '              THE WRITE PULSE.

D0       2        '       DATA LINES
D1       3        '
D2       4        '
D3       5        '



E     19          '              THE OUTPUTS
F     18          '                         A
D     17          '                       F   B
G     16          '                         G
C     15          '                       E   C
A     14          '                         D
B     13          '


START.

A          := /D3*/D2*/D1*D0   + /D3*D2*/D1*/D0
           + D3*/D2*D1*D0 + D3*D2*/D1*D0;

B          := /D3*D2*/D1*D0 +  /D3*D2*D1*/D0
           + D3*/D2*D1*D0
           + D3*D2*/D1*/D0 + D3*D2*D1;

C          := /D3*/D2*D1*/D0 + D3*D2*/D1*/D0 +
           D3*D2*D1;

D          := /D3*/D2*/D1*D0 + /D3*D2*/D1*/D0
           + D3*/D2*/D1*D0
           + D3*/D2*D1*/D0 + D2*D1*D0;

E          := /D3*/D2*D0 + /D3*D2*/D1
           +/D3*D2*D1*D0 +D3*/D2*/D1*D0;

F          := /D3*/D2*D1 + /D3*/D2*D0 +
           /D3*D2*D1*D0 +
            D3*D2*/D1*D0;


G          := /D3*/D2*/D1 + /D3*D2*D1*D0 +
           D3*D2*/D1*/D0;


End;
```

lights the LED. It sinks current from the appropriate segment of the display and a series resistor. This means a common anode display is necessary. Sorry, I know you've all got a bucket full of common cathode displays, but the PAL can not be trusted to source sufficient current and the additional driver circuitry is just a waste.

The eight LEDs are added to monitor the four power rails and four bus signals (OSC, CLK, MEMR and RES).

Part of the prototyping process was to lend the POST card

Listing 3.

```
10 CLS
20 PRINT "POST-CARD TEST PROGRAM"
30 PRINT "A.R.JARDINE S.M.SMITH"
40 PRINT "8/6/94"
50 PRINT
60 port = 128
70 A = 0
80 OUT port, A
90 PRINT "00 SHOULD BE DISPLAYED - TESTING
STUCK          DATA LINE AND ALL IC's"
100 SLEEP 2
110 FOR X = 0 TO 7
120 A = 2 ^ X
130 IF X < 4 THEN PRINT "0";
140 PRINT HEXS(A); " SHOULD BE DISPLAYED -
TESTING                 DATA LINE  D"; HEX$(X);
150 PRINT "  AND IC"; HEX$(3 + (X > 3))
160 OUT port, A
170 SLEEP 2
180 NEXT
190 OUT port, 255
200 PRINT "FF SHOULD BE DISPLAYED - ALL DATA
LINES          ON - TEST ALL IC's"
210 SLEEP 2
220 PRINT "0";
230 FOR X = 0 TO 15
240 A = X * 16 + X
250 OUT port, A
260 PRINT HEX$(A); " SHOULD BE DISPLAYED -
TESTING                 DISPLAY DECODERS IC2 +
IC3"
270 SLEEP 2
280 NEXT
```

to a friend. As the PCB can be inserted either way around into the PC, he inserted it the wrong way. (Thanks Pete!) R16-19 were incorporated in series with some of the address lines. These stop the power rails, ±5V and ±12V, from doing unspeakable things to the poor defenceless PAL when the PCB is inserted incorrectly.

The PAL Programs.

As mentioned earlier, IC1 produces an enable signal when an address of 80Hex is detected and the control signals are low (see Figure 2).Listing 1 contains the logic to do this and requires no explanation to anyone familiar with Boolean logic.

Listing 2, however, is far more complex as it decodes a four bit binary word into a hexadecimal representation on a conventional seven segment display. The workings of this logic are best explained with the aid of table 1. Table 1a lists all the hexadecimal digits and the segments of the display used to represent it. As you can see the list in table 1b, the number of digits to encode is long and complicated. It can be simplified with a small piece of lateral thinking, don't turn the segments on, but turn them off. This allows simpler logic expressions to be generated, table 1c. Careful study of listing 2 will reveal that the codes (0-F) defined in the logic are those that turn off the segments.

(e.g. the digit A (D3*/D2*D1*/D0) is only decoded by segment D because all the others are listed in table 1.) The order of the outputs from this PAL may seem strange until you look at the PCB layout. The connections from the PAL, via the resistors, to the display are all solder side without any need to change side. This simplicity comes from careful design of the PCB and PAL logic in unison. A simpler layout was possible but only at the expense of creating two different designs, one for each digit.

Construction.

Please read through this section thoroughly before starting construction. Building this project is greatly simplified if the PCB is used, (Figure 3). If you make your own boards and do not have the facility to make plated through holes, you will appreciate that the board has a number of loops to aid soldering components' side connections. Using a readers service board should not present any problems to an experienced constructor.

Firstly populate the resistors and capacitors. R1-14 are the current limiting resistors for the seven segment display and so their value defines the displays brightness, 1K is advised as any lower may be too much for the PALs and cause them to overheat. We have found that 4k7 is a good value for the protection resistors (R16-19) as any lower may not provide enough protection and any higher might interfere with the logic levels. The electrolytic, C1, is of course polarised and +ve is at 5V (that also on the common anode of the display). The LEDs are next with all the anodes towards the text above them. The dual seven-segment display has its pin 1 nearest to IC2. For enhanced visibility it is possible to use a right angle socket to mount the display. This allows the display to be read from above when the card is inserted into the PC, but the card is hardly low profile any more and as a consequence becomes prone to damage. Last and by no means least are the PALs. These are the only static sensitive parts used and are best socketed.

Great care must be taken when soldering to avoid solder bridges between adjacent points, as the consequence could be PC destruction. Visually check all joints and all top side connections.

Testing.

To test your completed POST card check continuity between the supply rails, as a short here could very damaging. Once you are confident about its safety install it in your PC, when it is switched off, making sure the card is the right way around and you can see the display and LEDs clearly. Now turn on your machine watching the display, it should sequence through a set of numbers If the PC does not start up properly shut it off immediately and check that the card is inserted the correct way around, with the writing on the card giving you directions. Now your card should be installed the correct way around and free from shorts.

All eight status LEDs will now be lit. The MEMR LED may be dim or flicker depending upon the amount of access to the memory. If this LED is out try doing something on the PC that involves allot a screen updating, as this will cause the buses' MEMR signal to be activated. If the LEDs do not light check that they are the correct way around (anode towards the writing).

The address decoding and display drivers can be tested with the small BASIC program in listing 3. As the POST card is at input/output address 80Hex you can talk to it directly by outputting a byte to this address. In Qbasic that is "out &H80,byte", where byte is the number you wish to send to the

Table 1

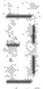
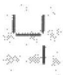
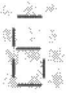
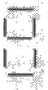
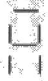
Digit	Display	Segments
0		a,b,c,d,e,f
1		b,c
2		a,b,d,e,g
3		a,b,c,d,g
4		b,c,f,g
5		a,c,d,f,g
6		a,c,d,e,f,g
7		a,b,c
8		a,b,c,d,e,f,g
9		a,b,c,d,f,g
A		a,b,c,e,f,g
B		c,d,e,f,g
C		a,d,e,f
D		b,c,d,e,g
E		a,d,e,f,g
F		a,e,f,g

Table 1b List of segments on.

Segment	Codes
a	0,2,3,4,5,6,7,8,9,A,C,E,F
b	0,1,2,3,4,7,8,9,A,D
c	0,1,3,4,5,6,7,8,9,A,B,C,D
d	0,2,3,5,6,8,B,C,D,E
e	0,2,6,8,9,A,B,C,D,E,F
f	0,4,5,6,8,9,A,B,C,E,F
g	2,3,4,5,6,8,9,A,B,D,E,F

Table 1c List of segments off.

Segment	Codes
a	1,B,D
b	5,6,B,C,E,F
c	2,E,F
d	1,4,7,9,A,F
e	1,3,4,5,7,9
f	1,2,3,7,D
g	0,1,7,C

card. The supplied program tests for shorted data lines (walking ones) and each digit in the display driver.

Buylines.

The PAL used in the prototype was a PALCE16V8 from AMD. This was chosen because it's cheap (about £1.50). If it is however not readily available, any CMOS 16V8 or 18CV8 could be programmed to do exactly the same job. All items are available in Maplin, so almost anywhere stocks the parts. (We should have a source of programmed chips. See next month's issue for details. Ed)

Now you have built and tested your POST card you will want to use it. How do you use it? We will tell you next month.

Watch this space...

PARTS LIST

Resistors (1/4W 5%)

R1-14,R20-23,R26,R27	1K
R15-19	4K7
R24,R25	1k2

Capacitors

C1	10-100uF 16V Electrolytic
C2	0.1uf Ceramic

Semiconductors

IC1-3	PALCE16V8 (or 18CV8)

Optoelectrical

LED1-8	3mm LEDs, colour to taste, High efficiency if prefered.
DD	Dual Seven Segment Display common anode (0.56'). eg from Maplin BY66W or high effeciency type if preferred.

Miscellaneous

PCB

IC sockets if required.

HALL EFFECT SWELL PEDAL

With this project from Robert Penfold you too can make swell music

A traditional swell pedal is basically just a logarithmic potentiometer used in standard volume control fashion, and controlled via a foot-pedal instead of an ordinary control knob. It enables players of electric and electronic instruments to control the volume while still using both hands to play their instruments. Although there may seem to be no point in trying to improve on such a simple piece of equipment, over the years there have been various attempts at producing improved swell pedals. Practical potentiometer type swell pedals do sometimes have one or two shortcomings.

A common complaint about ordinary swell pedals is that they tend to be rather noisy when operated. This is actually a problem with many effects units that are controlled via a potentiometer, and is a byproduct of the rather crude way in which most potentiometers operate. There are various ways around this problem, one of which is to use a voltage controlled attenuator (VCA). The potentiometer is used to provide the control voltage for the VCA, rather than directly controlling the input signal. The control voltage from the potentiometer is fed through a simple lowpass filter which removes all or most of the audio frequency noise, and gives scratch-free control of the volume.

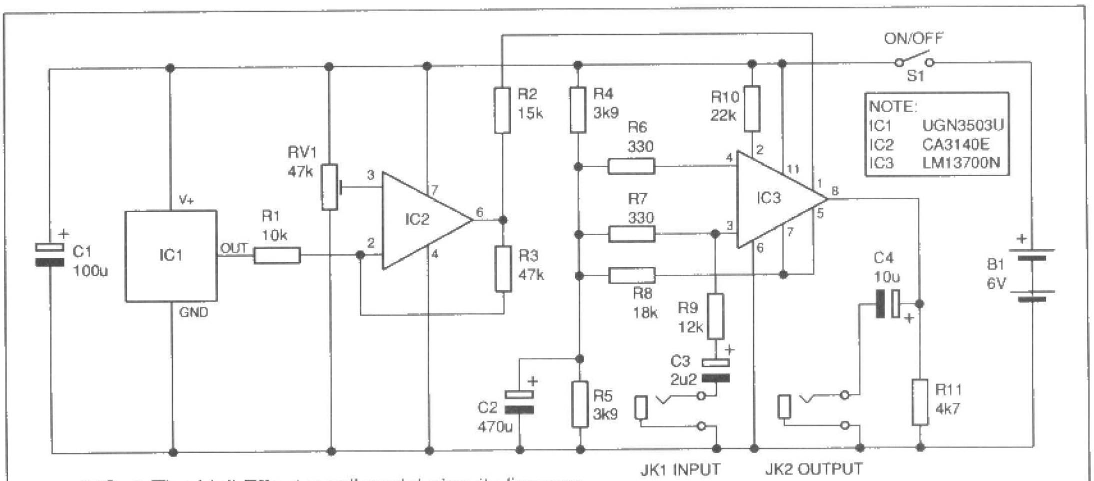
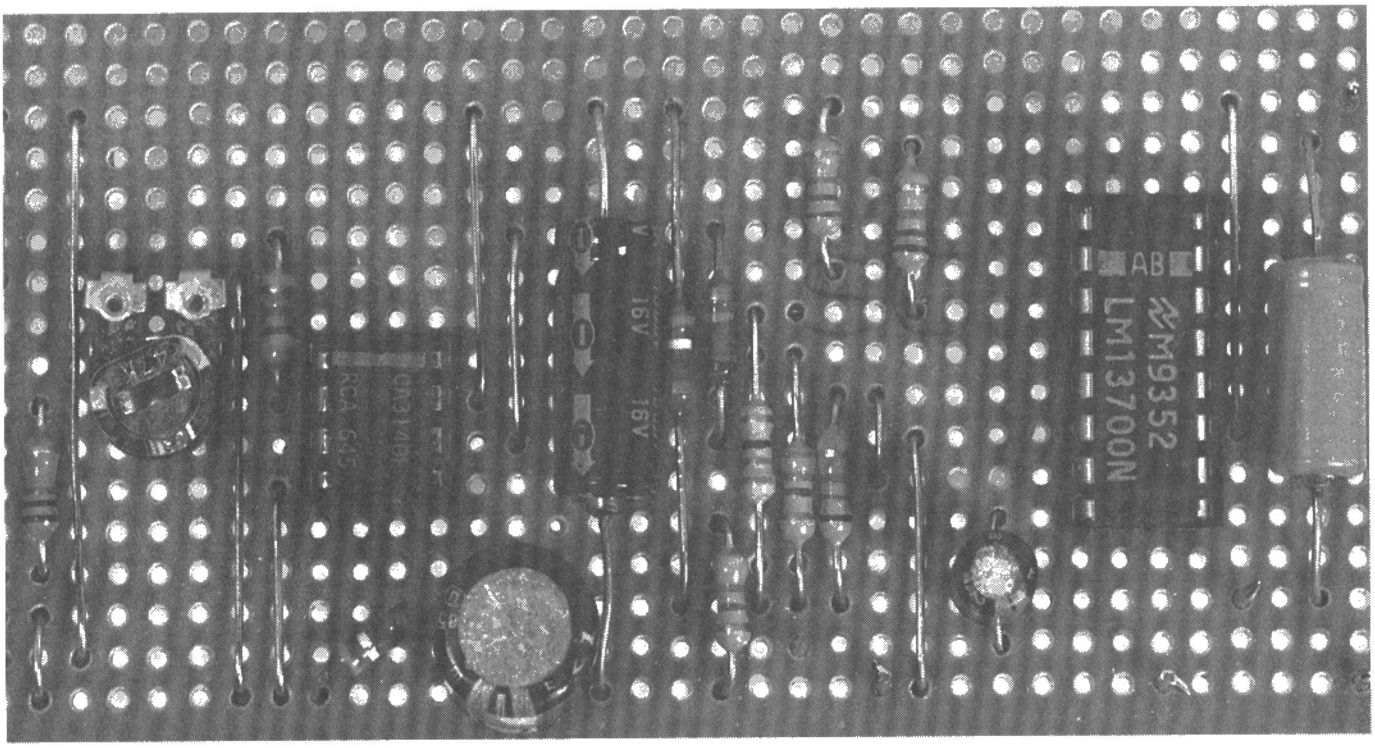


FiG. 1 The Hall Effect swell pedal circuit diagram



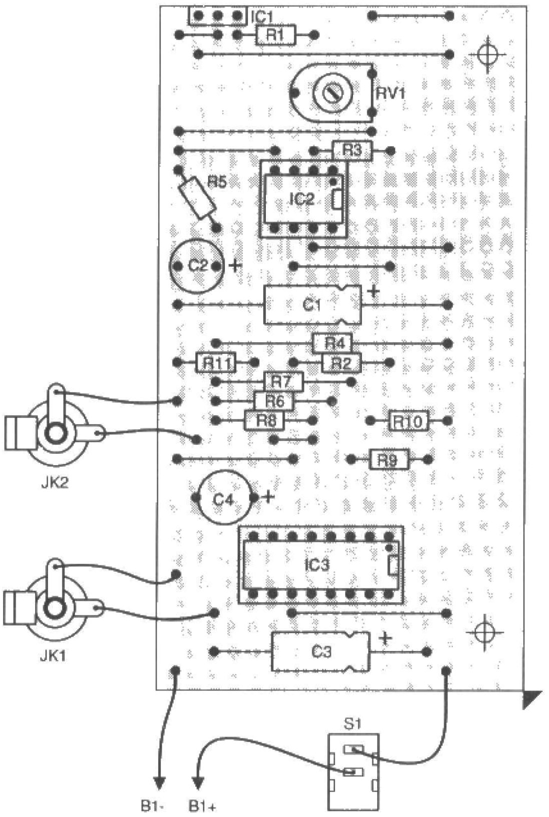


FIG. 2 The stripboard component lasyout and wiring

Hall Effect

This swell pedal design uses a variation on this method. The potentiometer is dispensed with altogether, and the control voltage is instead provided by a linear Hall Effect device. Hall Effect devices may be unfamiliar to many readers, since they are not exactly the type of thing you use in every other project. A component of this type is a semiconductor device which can detect a magnetic field. In the case of a linear Hall Effect device the quiescent output voltage is about half the supply voltage. A magnetic field of one polarity produces a rise in the output voltage, and a magnetic field of the opposite polarity produces a reduction in the output potential. The change in output voltage is proportional to the strength of the applied magnetic field.

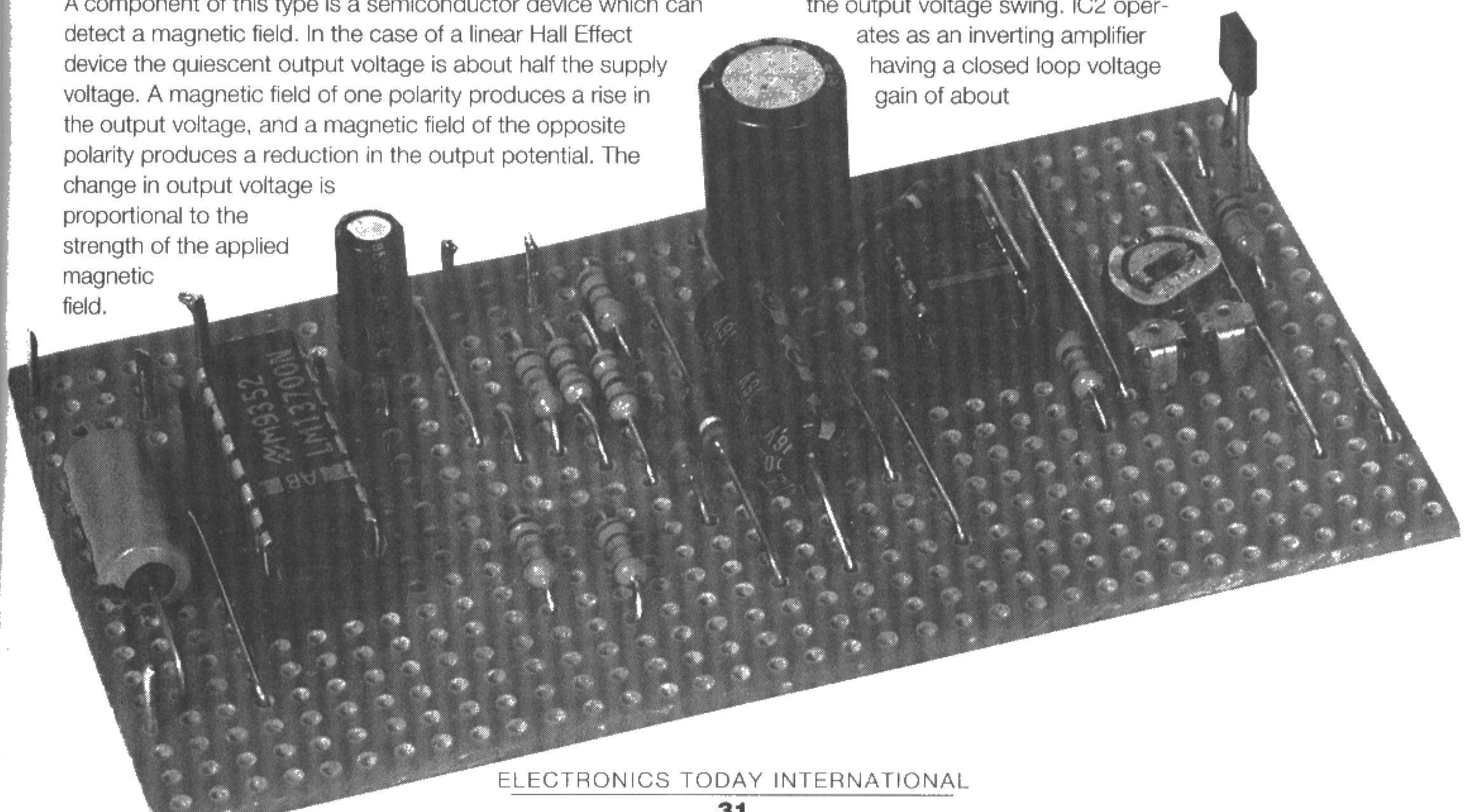
When used in a swell pedal, the magnetic field is provided by a small bar magnet mounted on the pedal. When the pedal is depressed the magnet is brought closer to the sensor, a higher output voltage is produced, and the losses through the VCA are reduced. This gives noise-free control of the volume, and it is not even necessary use lowpass filtering on the output from the Hall Effect sensor. Unlike using a potentiometer, this method of generating the control voltage is inherently noise-free.

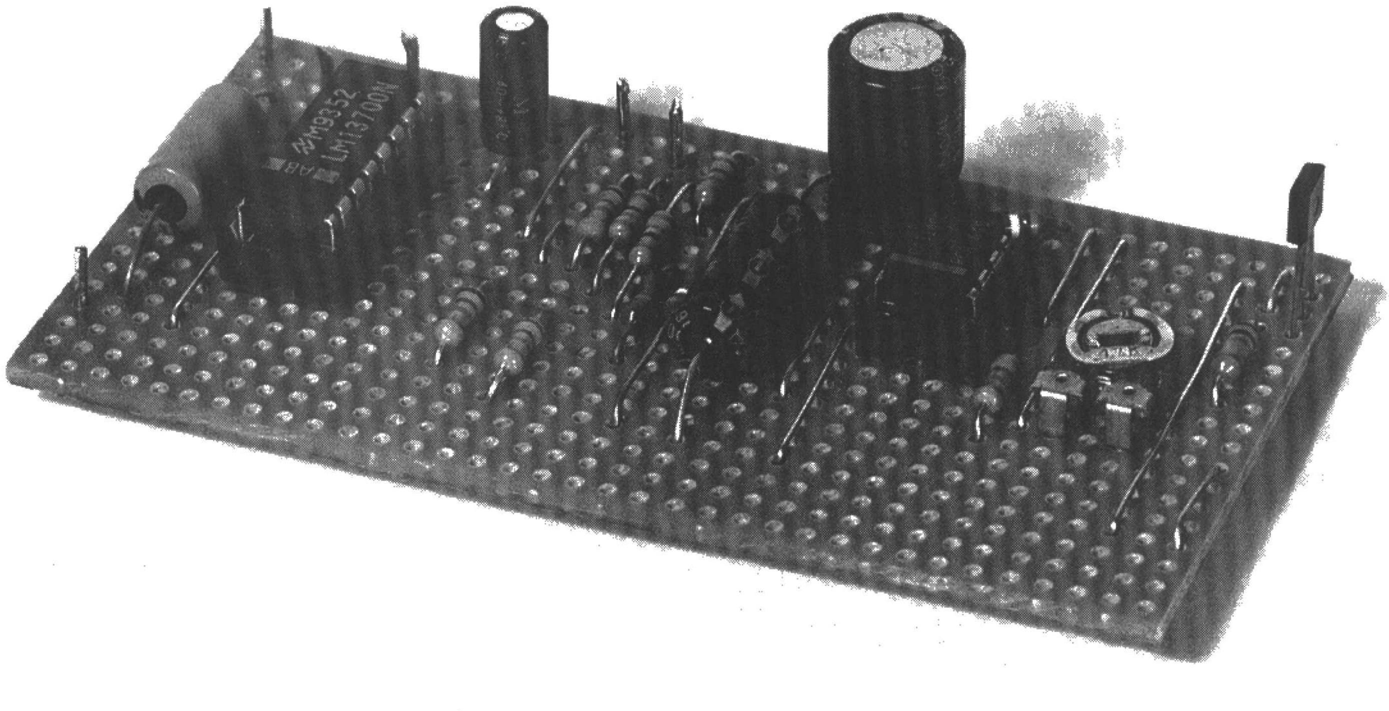
Hall Effect swell pedals are by no means a new idea, and they were first produced more than ten years ago. At one time units of this type tended to be expensive due to the relatively high cost of linear Hall Effect devices. Some linear Hall Effect sensors are still quite expensive, but there are now some low cost devices which have a level of performance that is more than adequate for the present application. The sensor used in this design is available for less than one pound, which makes it slightly cheaper than the magnet used to activate it!

An advantage of the Hall Effect method for the home constructor is that it avoids the need for a complex pedal mechanism. There is no need for gears or pulleys to provide a coupling between the pedal and a potentiometer. All that is needed is a very basic pedal mechanism fitted with a small bar magnet. Even someone who is not particularly good at the mechanical side of project construction should be able to improvise a usable pedal mechanism.

How It Works

The circuit diagram for the Hall Effect swell pedal appears in Fig.1. IC1 is the Hall Effect sensor, and this three terminal device is very easy to use. A supply voltage of between 4.5 and 8 volts is applied to the appropriate two leads, and the output voltage is taken from the third terminal. The UGN3503U contains a Hall Effect sensor, a linear amplifier, and an emitter follower output stage. It is not particularly sensitive though, and even with a small bar magnet right against the device a change in output potential of no more than about one volt is obtained. IC2 is therefore used to provide a boost in the output voltage swing. IC2 operates as an inverting amplifier having a closed loop voltage gain of about





five times, and it also provides level shifting. VR1 is adjusted to bias the non-inverting input of IC2 to a level that produces an output voltage that is close to zero with the magnet withdrawn from IC1.

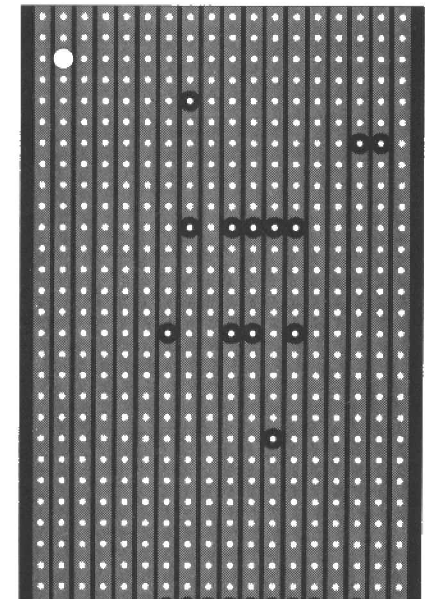


FIG. 3: The underside of the component panel

Applying the magnet to IC1 with the correct polarity results in its output voltage reducing, which in turn gives an increase in the output voltage from IC2. This enables IC2's output potential to be varied between about 0 and 4.5 volts by applying and withdrawing the magnet. This is sufficient to give a widecontrol range from the VCA.

The VCA is based on one of the transconductance amplifiers in IC3, and it is of conventional design. The other section of IC3 could be used in an identical VCA circuit if a stereo swell pedal is required. R4, R5, and C2 provide a centre-tap on the supply lines that is used to bias the inputs and output of IC3. R10 provides a bias current to the linearising diodes in IC3, and this gives reduced distortion at high signal levels. R11 is the discrete load resistor for the built-in emitter follower output stage.

Strictly speaking, the LM13700N is current rather than voltage controlled, and the circuit is a CCA (current controlled attenuator) rather than a VCA. However, R2 is connected in series with the control input of IC3, and the current flow here is roughly proportional to the input voltage. The circuit therefore provides a normal VCA action, and the attenuation is governed by the output voltage from IC2. The circuit has approximately unity voltage gain with maximum control voltage from IC2. It should provide around 80 to 90dB of attenuation with zero control voltage from IC2.

The current consumption of the circuit is only about 12 milliamps. Four HP7 size cells in a plastic holder are a more than ample power source.

Construction

Details of the stripboard and wiring are provided in Figs.2 and 3. The board has 35 holes by 18 copper strips. Note that IC1 has a PMOS input stage, and that it therefore

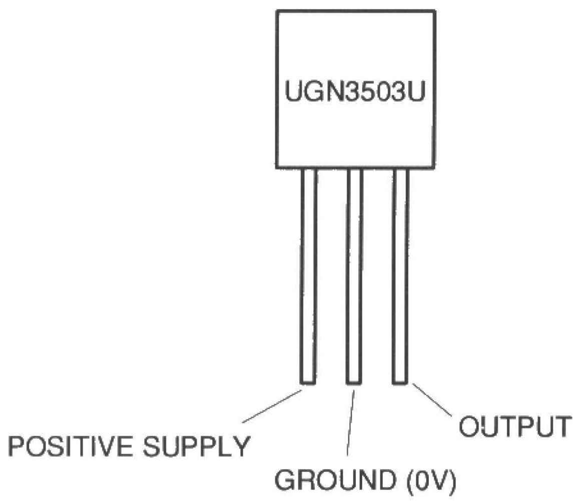


FIG. 4: Identifying the UGN3503U leadout wires

requires the normal anti-static handling precautions. In particular, use a holder for this device, and do not fit it into place until the board and all the wiring have been completed. The CA3140E used for IC2 is a type that will work properly in single supply DC amplifiers. Most other operational amplifiers (uA741C, TL081CP, LF351N, etc.) will not operate properly in this circuit. Although an LM13700N is specified for IC3, the LM13600N will work just as well. These two devices would seem to be practically identical. Retailers now seem to supply the LM13700N, but if you have an LM13600N in the spares box it is perfectly suitable for use in this project.

IC1 is one of those awkward symmetrical devices which make it difficult to determine the correct orientation. The best method seems to be to use the type number to differentiate between the notional front and rear sides of the device. Fig.4 shows how to identify the three leadout wires using this method. As viewed in Fig.2, the type number is on the right. Of course, in order to get the sensor in the right position relative to the magnet it might be necessary to mount it off-board. It can then be fitted on a small piece of stripboard, and wired to the main unit via a short three-way lead.

It should not be difficult to produce a simple pedal mechanism. Basically all that is required is a large hinge bolted to a sheet of 16 s.w.g. aluminium. The positioned of the magnet on the pedal should be selected to provide a movement of about 15 millimetres or so. I found that the Maplin "large" and "small" magnets both provided good results, but the "large" type is the more practical choice. It is easier to glue this in position on the underside of the pedal, and its alignment with the sensor is far less critical. Any similar magnets should also be suitable, but I have only tested the circuit with the two Maplin magnets. Small bar magnets do not normally have anything to show their polarity, so the correct orientation for the magnet must be found using trial and error. With any form of pedal style project it is advisable to use a fairly tough case. A diecast aluminium box is ideal, but I have always found simple folded aluminium boxes to be adequate for this type of thing. It is advisable not to use a plastic case for a project of this type.

Note that the unit will only function properly if the correct pole (end) of the magnet is applied to the appropriate face of the sensor. Applying either pole of the magnet to an edge of the sensor will not significantly vary the control voltage to the VCA. Neither will applying the middle of the magnet to any part of the sensor. It does not matter which face of the sensor the pole of the magnet is applied to, provided it is the correct pole for that face. The four HP7 (AA) size cells are fitted into a plastic battery holder. Connections to this holder are made via a standard PP3 type battery clip.

Adjustment

VR1 must be given the correct setting before the unit will function properly. The unit should pass the input signal straight through to the output if VR1 is set almost fully clockwise. Slowly backing off VR1 in a counter-clockwise direction should soon produce a reduction in the output level. VR1 should be backed off just far enough to give a high level of attenuation through the unit. By applying the magnet to VR1 it should then be possible to control the output level, and to vary it over a wide range.

PARTS LIST

HALL EFFECT SWELL PEDAL

Resistors (0.25 watt 5% carbon film)

R1	10k
R2	15k
R3	47k
R4,R5	3k9
R6,R7	330R
R8	18k
R9	12k
R10	22k
R11	4k7
VR1	47k min hor preset

Capacitors

C1	100u 10V axial elect
C2	470u 10V radial elect
C3	2u2 50V axial elect
C4	10u 25V radial elect

Semiconductors

IC1	UGN3593U
IC2	CA3140E
IC3	LM13700N or LM13600N

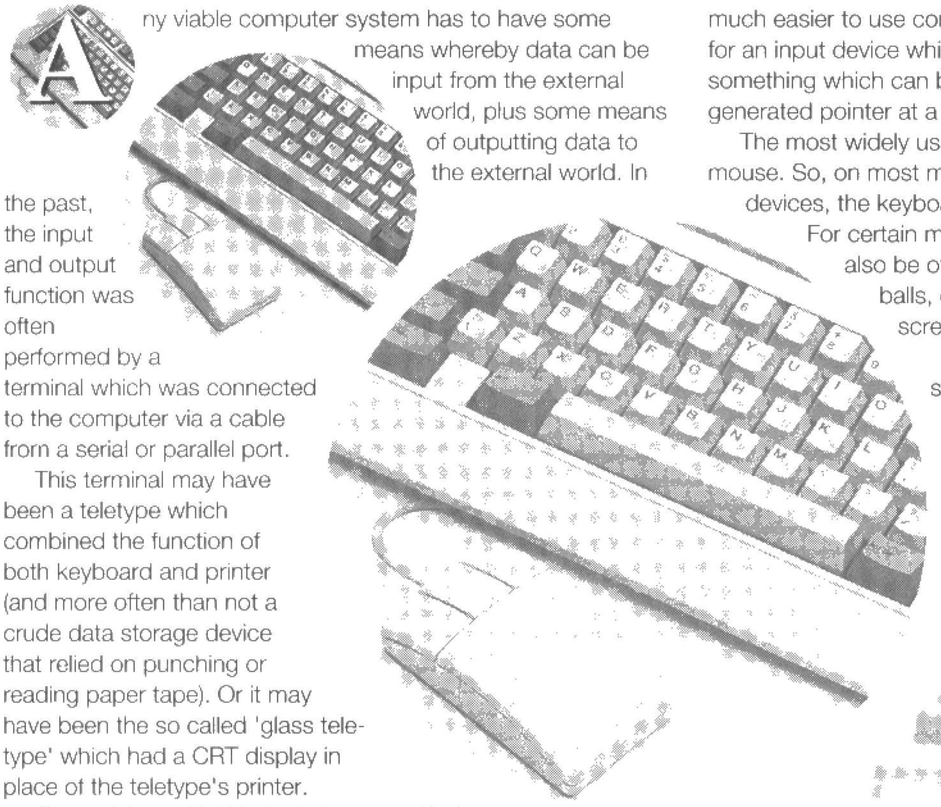
Miscellaneous

JK1,JK2	standard 6.35mm jack socket
S1	SPST min toggle
B1	6 volt (4 x HP7 size cells)

Case, 0.1 inch stripboard having 35 holes by 18 copper strips, battery connector (PP3 type), plastic battery holder, Maplin "large" magnet, materials for pedal, 8 pin DIL IC holder, 16 pin DIL IC holder, wire, solder, etc.

PC Clinic

This month in PC Clinic, we examine in depth two of the most commonly used data input devices on a PC, the keyboard, and pointing devices or mice, as well as taking a quick look at some of the other less frequently encountered input devices.



Any viable computer system has to have some means whereby data can be input from the external world, plus some means of outputting data to the external world. In the past, the input and output function was often performed by a terminal which was connected to the computer via a cable from a serial or parallel port.

This terminal may have been a teletype which combined the function of both keyboard and printer (and more often than not a crude data storage device that relied on punching or reading paper tape). Or it may have been the so called 'glass teletype' which had a CRT display in place of the teletype's printer.

The problem with this technique was that the data transfer rate was quite slow on account of transmission, and terminal, hardware limitations. Thus a typical teletype would operate with a data transfer rate of 300baud, or just 30 characters per second. Video terminals tended to work faster, but anything above 9600baud, or 960 characters per second, was uncommon.

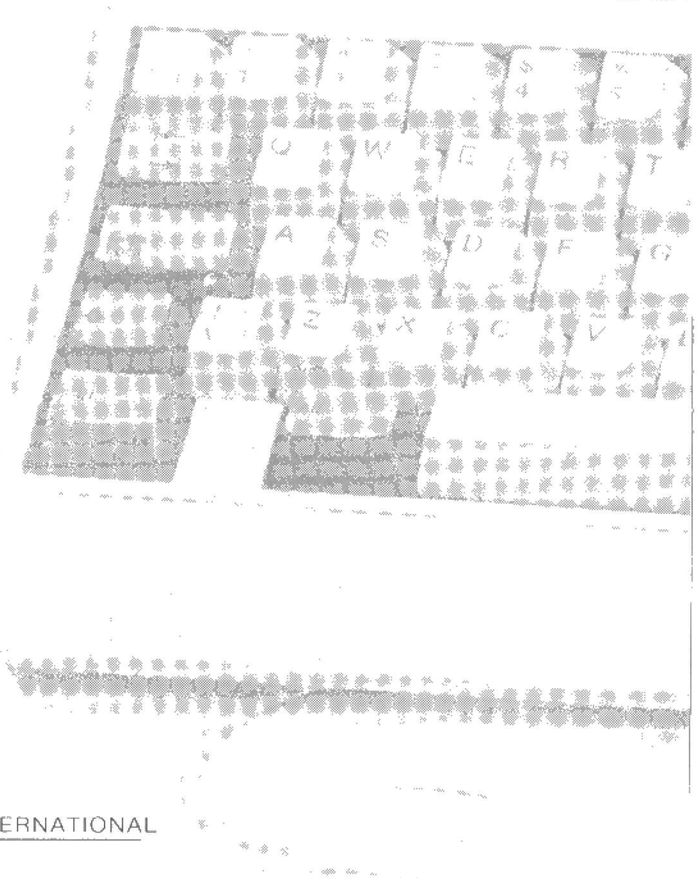
Although this type of data transmission speed is ample for user data input from a keyboard it is obviously totally inadequate for generating the type of graphics displays found on the PCs of today. Hence, this use of a separate terminal for input and output was abandoned quite early on in the development of personal computers. It was abandoned in favour of the currently used fully integrated system where computer, keyboard and monitor were all part of the same unit.

In other words, the terminal and the computer have been merged together. The video display is now connected to special high speed circuitry that interfaces directly with the processor bus and allows for the rapid generation of high resolution images. However, the keyboard is still connected to an input port and, in hardware terms, has hardly changed since the first PC was introduced.

The availability of high resolution, high speed, colour graphics displays has led to the almost universal use of graphical user interfaces such as Windows. Such GUIs have made it much easier to use complex applications software, but they call for an input device which is more versatile than the keyboard, something which can be used to quickly position a software generated pointer at a desired location on the screen.

The most widely used solution to this requirement is the mouse. So, on most modern systems, there are two main input devices, the keyboard and the two or three button mouse. For certain more demanding applications there may also be other types of input device such as track balls, digitising pads, light pens and touch screens.

In this issue of PC Clinic (unfortunately shortened as a result of having to include a four page reader survey) we will be looking at all these different input devices as well as looking at how to repair and maintain two of the devices which most frequently fail on a PC, the keyboard, and the mouse.



The keyboard.

Since the keyboard on a PC is the one piece of it that we use the most it is hardly surprising that it is also the bit that suffers most from continued use. Few of us will have had a motherboard fail, or a hard disk crash, but I suspect a great many readers will have had a keyboard fail in one way or another. Sometimes the whole keyboard will not work properly, sometimes just a single key.

Besides simple wear and tear through constant use, the main reason for keyboard failure is the fact that they are very vulnerable to dust, hair, dirt, and a thousand and one other sorts of detritus, not to mention the spilled cup of coffee, that can collect under the keys and stop them working properly.

Keyboards used on most PCs are a standard form and therefore mass-produced and not that expensive to replace, but if a keyboard fails it can be well worthwhile trying a few simple maintenance procedures that could easily get it working again. Even if the keyboard has not failed, then a regular clean may well ensure that it has a much longer usable life. A factor which might be very important in the case of non-standard keyboards such as those used on portable and notebook computers.

Probably the commonest problem with a keyboard is that one or more keys stop working completely, or work only intermittently. Of course, this may be due to the hardware, in particular the switch contacts, wearing out. This is a particular problem with keys which are used a lot. In such cases the only course of action is to replace the entire keyboard.

However, unless the keyboard is very heavily used and quite old it is more likely that something has simply become wedged between the switch contacts, stopping them from working properly. In such cases all one needs to do to get the keyboard working again is to open up the keyboard and clean out the accumulated dust and dirt. In fact, to prevent failure it is a good idea to do this three or four times a year.

To clean the keyboard, first disconnect it from the PC and, after turning it over, carefully remove all the screws that hold the two halves of the case together. Having done this keep the keyboard upside down and remove the case bottom. This will expose the keyboard PCB inside. This PCB is attached to the key assembly by about twenty small screws. Carefully remove them and put aside.

Once all the screws holding the keyboard PCB to the key assembly have been removed, one can then simply turn over the PCB to expose the contacts. The key caps will remain in place in the upturned keyboard case. With the contacts exposed, it is a simple matter to brush away the dust and dirt with a small soft brush and compressed air (use one of the compressed air cans sold as Spray Duster).

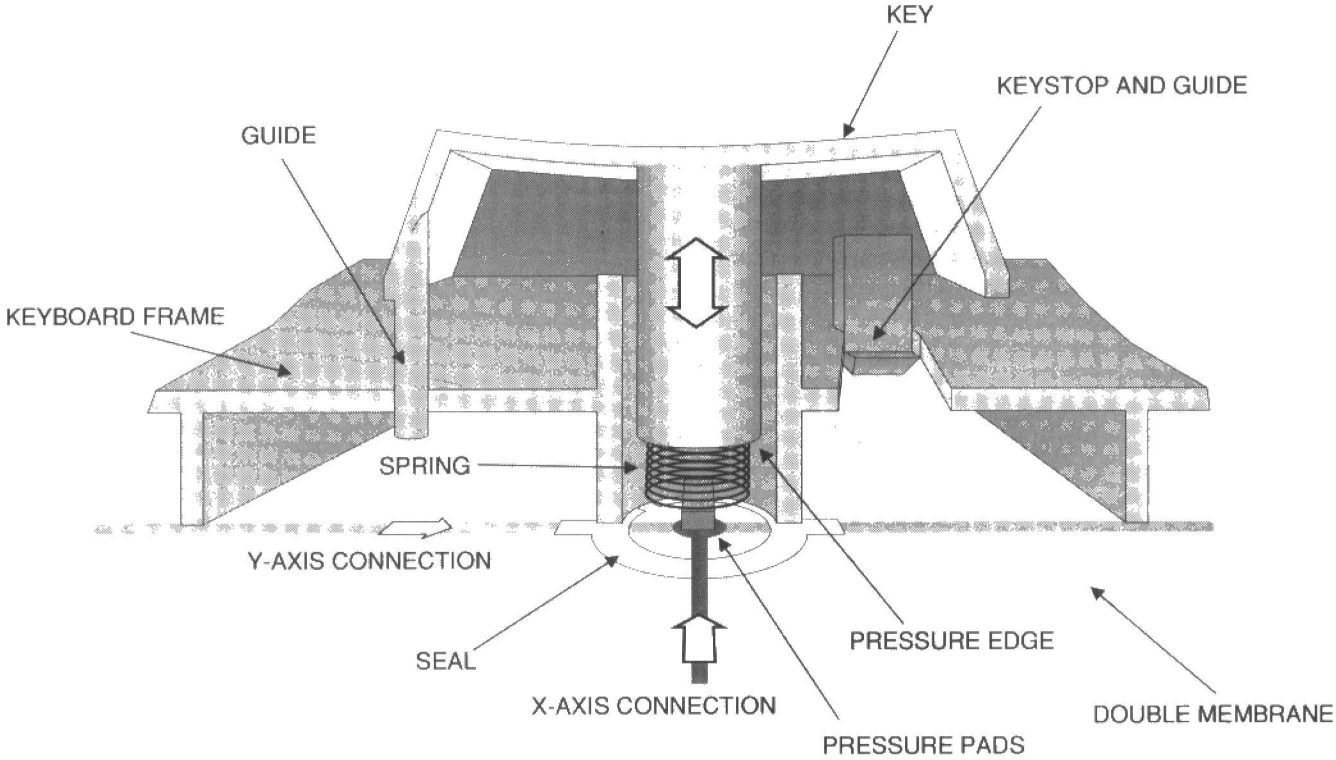
If the contacts are very dirty then you may well need to give them an additional clean by rubbing them over with a soft cloth soaked in alcohol (it is important that the cloth is not abrasive and that you do not rub too hard) .

You will definitely need to do this if the cause of the problem was a drink spilled into the keyboard. Use plenty of alcohol (surgical spirit, not methylated spirit since the latter will leave a residue) and let it dry for about an hour before reassembling. You may also need to clean the actual keys as well; cotton tipped swabs are useful for this purpose.

If you have to remove any of the keys for cleaning, then take particular care when popping them off the key assembly. Check underneath for a little spring wire. If this wire exists, it is safest to leave the key where it is and clean it as best one can in situ. This is because it can be extremely difficult to replace these minute springs once they have been removed.

Once the keyboard has been cleaned, carefully reassemble by replacing all the screws that fasten the PCB to the key assembly. Reattach the back of the case and plug it into the PC. With a bit of luck, it should work perfectly.

The diagram on this page shows the inner working of a single key on a typical PC keyboard. Note that the key is restrained to move by guide holes in the keyboard frame. A small lip on keytops ensures that the key is retained under spring pressure, the key pressure being set by the spring. Key depression is sensed by the bottom edge of the key pressing on a plastic membrane mounted underneath the keyboard frame. Conductive tracks are arranged to cross underneath each key so that when key is depressed a connection is made.

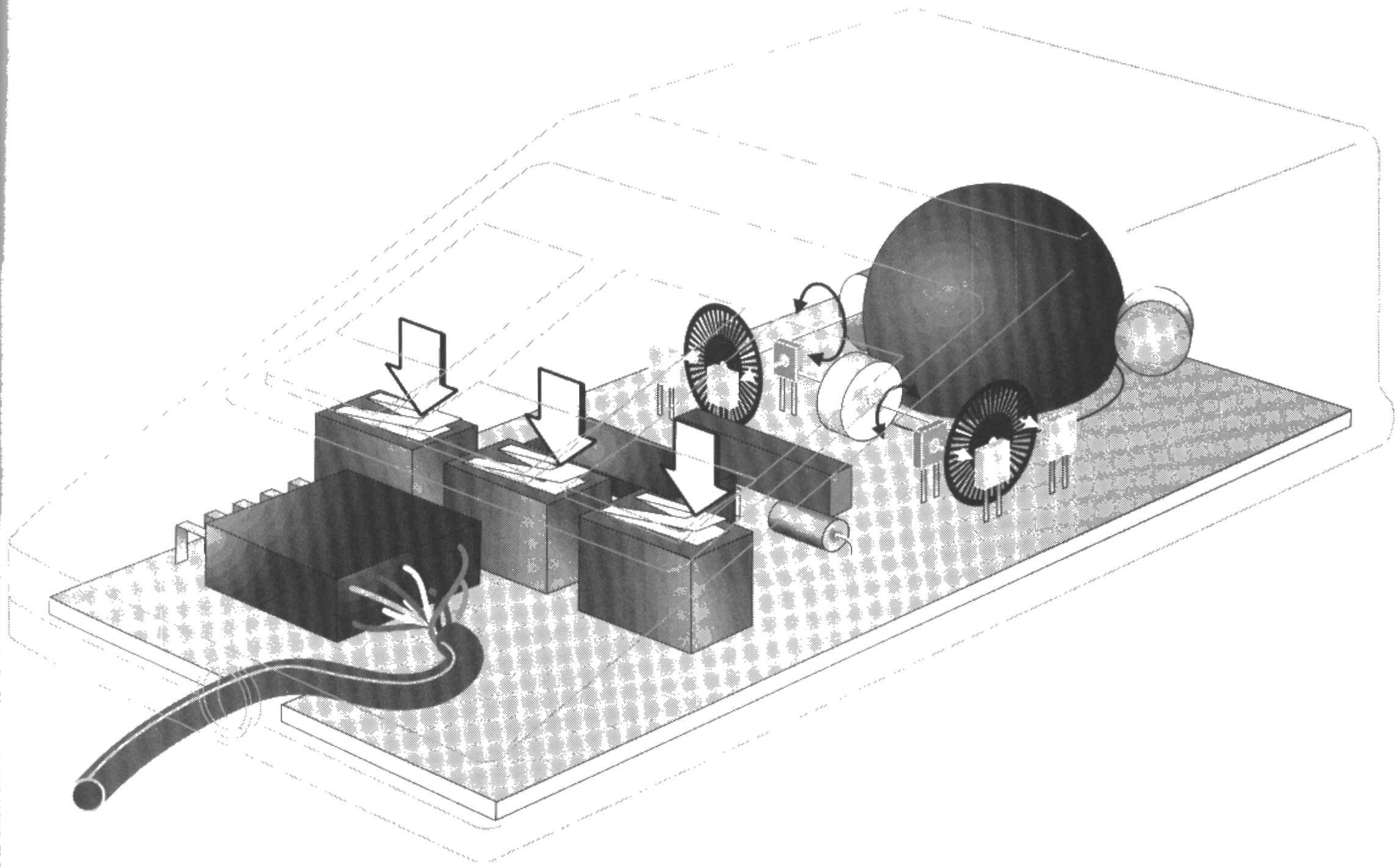


The Mouse.

The mouse is a relatively new type of computer data input device. It was initially developed by Xerox as part of their Xerox Star system, the first machine to use the now ubiquitous graphics user interface, the machine whose design inspired the Apple Macintosh.

It was the success of the Macintosh which led to the first widespread use of a mouse.This success in turn prompted the development of other graphics user interfaces, in particular Microsoft Windows. And it is the almost universal popularity of Windows amongst PC users which has seen the mouse become today as familiar an input device as the keyboard.

Mice come in a wide range of different types, there are mechanical mice, opto-mechanical mice, one-button mice, two-button, and three -button mice, but the basic function of all of them is the same. The function is to convert small movements of the mouse into digital signals which the system can translate into corresponding movements of an arrow pointer on the screen. These digital signals are in the form of X and Y co-ordinate values and are produced in the mouse by two rotary position sensors that are rotated in proportion to the direction of movement by a ball that touches the spindle of both sensors as well as the table top or mouse pad. The actuators are so designed that the system can detect the direction of rotation and are sufficiently sensitive to offer a resolution ranging from 200 dpi (dots per inch) to 400dpi.



The diagram on this page shows a three-button opto-mechanical mouse; the two rotating optical position sensors can be seen lying at 90degrees to each other and touching the mouse ball at a tangent. The spoked wheels are the optical sensor disks, with an LED on one side of the disk and a photo-transistor on the other (notice that a pair of sensors is used in each disk to provide rotational direction information. The three buttons are just microswitches.

With a purely mechanical mouse, the position and direction of the sensors is determined by having metal spokes etched onto the sensor wheel and little spring contacts detecting whether they are touching a conductive spoke.

With both the above sorts of mice, it is important that they are cleaned regularly. Dust and dirt easily collect on the surface of the ball as well as on the sensor spindles and will, if it gets too bad, reduce the efficiency of the mouse and produce jerky pointer movements. Efficiency will also be impared if dirt gets onto the sensor wheels, although this will only happen if the mouse picks up a lot of dirt. Regular cleaning of the mouse ball is the best preventative solution to all these problems, cleaning can be done with the aid of a special cleaning kit, or a soft cloth soaked in alcohol.

There is one sort of mouse which does not use a ball - the purely optical mouse. These work on a different principle, LEDs and photo-transistors in the mouse detect its movement over a special mat that is marked with a fine grid. This sort of mouse is a lot more expensive, but very reliable since it has no moving parts.

It should be noted that Windows allows one to configure the way in which the mouse works. You can swap left and right buttons, as well as changing the sensitivity to movement - the tracking speed, and the double click speed. To change these configurations, open the Control Panel, select the Mouse icon, and make the appropriate changes using the sliders or check box

Other Input Devices.

Besides the keyboard and mouse, a wide range of other user input devices exist for specialised applications. Applications where a conventional keyboard or mouse cannot be used or where they are insufficiently accurate. We shall take a brief look here at four of the commonest.

Trackballs

A track ball is essentially just an upside down mouse; instead of moving the mouse the user moves the ball. They are used in the same applications and for the same purpose as a mouse, and have become quite popular recently. There are two main reasons for this popularity, one is that many people find them ergonomically better than a mouse, and the other is that they can be used without a mouse pad or desk top.

The fact that they do not need the use of a mouse pad or desktop is of particular appeal to users of notebooks and portables. Indeed many portables are now being produced with either a built-in, or clip-on, track ball. The ergonomic appeal of a trackball is based upon the fact that it does not require so much movement to use and requires just a very light touch on the ball. It should be noted that trackballs have been used in military equipment for a long time and probably pre-date the introduction of the mouse.

Digitising Pads

For high accuracy work with computer graphics the problem with mouse and trackball type devices is that they use relative positioning of the pointer. In other words, they rely upon a hand/eye feedback to move the mouse in order to accurately position the pointer on the screen. As anyone who has attempted to use graphics design systems will know, this is not that easy

This limitation is overcome by a digitising pad which generates an absolute position of a stylus, or puck, as it is moved across the surface of a special digitising tablet. The tablets range in size from A4 upwards and in the most common systems generate the exact X, Y position on the tablet by means of a sensor in the stylus which detects the position from a grid of wires buried in the tablet.(Some systems work using acoustic positioning, others using a pantograph to which the puck is attached.)

On some systems there is also an additional sensor which allows the pressure on the point of the stylus to be measured. This allows the stylus to be used in exactly the same way as a pen or brush, heavier pressure produces a thicker, darker line, lighter pressure a thinner, fainter line.

The resolution of a digitising tablet ranges from under 100dpi to well over 300dpi. In addition to two dimensional digitisers, there are also three dimensional digitisers which allow an object to be described in three dimensions. Such systems are very specialised and therefore tend to be very expensive.

Touch Screeens

Touch screens are widely used in applications where it is undesirable to have a keyboard attached to a system. Such applications range from industrial control systems where a keyboard is inappropriate because of the environment in which the system is located (too much dirt, etc), to applications where the system is used by the general public for data queries and it needs to be kept as simple as possible.

There are a range of different technologies used in touch screens. They range from ultrasonic or infra-red based detectors that work on an 'echo location' principle to locate the touching finger, to transparent conductive screens which measure capacitive changes when touched. They usually fit over the existing monitor screen and are connected to the system via the serial port.

Most touch screen systems have a fairly low resolution and obviously have to be used in conjunction with the appropriate software to generate the key legend on the screen underneath a specific area, and then detect whether that area has been touched.

Light Pens

Light pens are an interactive graphics tool rather like the digitiser pad and stylus since they can be used to directly draw lines on the screen or point to specific parts of the screen, rather than via the mouse pointer. Again it is more like using a pen or pencil.

Light pens were, in fact, some of the first graphics input devices ever used, and have been around for about 25 years. Today they are not widely used; users prefer either the mouse or a digitising tablet. However, provision for a light pen was provided on the now defunct IBM PC Junior, and some light pen support routines are still to be found within BIOS.

Light pens most commonly work by a photo detector in the pen tip to detect the monitor scan and then use this information to calculate the exact position of the pen tip on the screen. The monitor scan can be replaced by detecting a software generated scanning pixel.

Future ETI projects for PC owners.

We have some interesting PC based projects in the pipeline, which will be published over the next few issues. These include: a parallel multi-port for connecting experiments to your PC via the parallel port; a PC anti-theft device; a PC controlled EPROM programmer and emulator; a versatile PC based touch screen; a PC based logic analyser for troubleshooting digital circuits, and a light pen for interactive graphics on a PC. For the more advanced reader, we have a three dimensional digitiser for converting solid objects into an array of data points, and a computer controlled drilling machine.

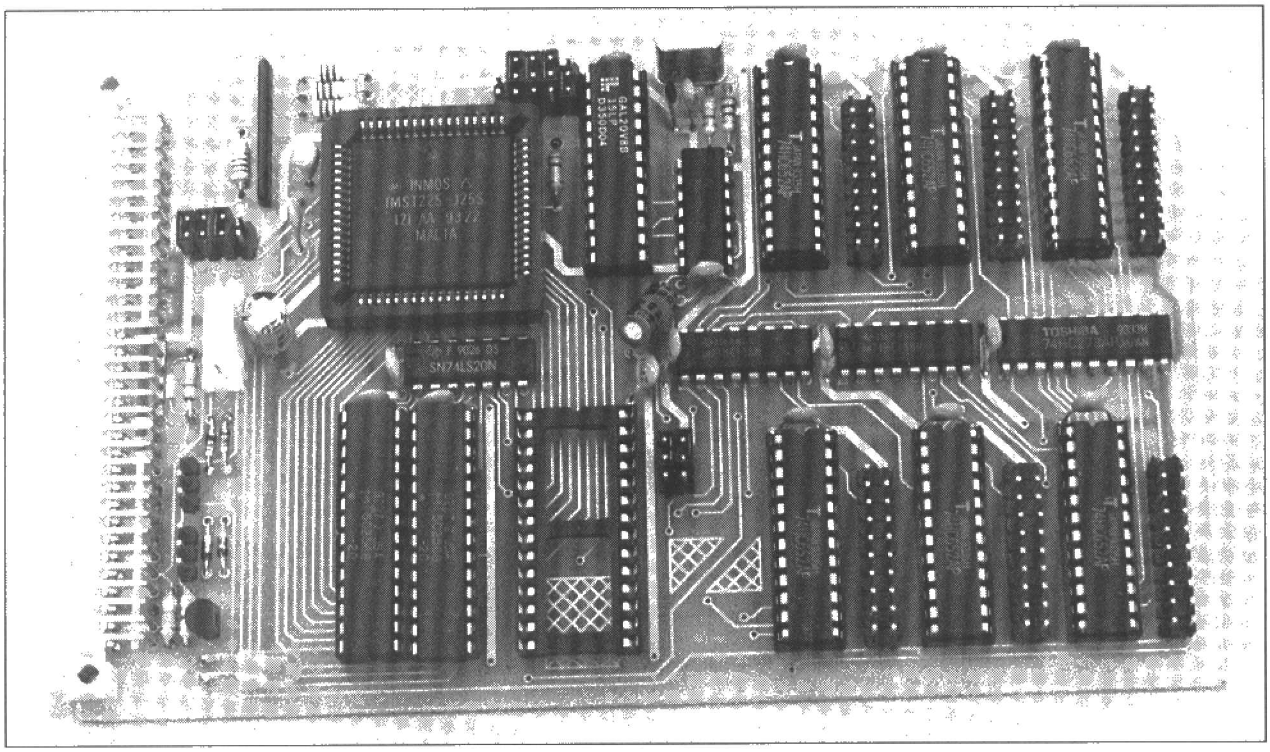
Indeed, over the coming year we will be bringing PC owning readers of ETI a whole range of interesting and useful projects which can be added to your PC. In order not to miss them, why not subscribe to ETI, or put in a regular order with your newsagent?

ETI is THE magazine for electronics and gadget minded PC owners.

Next....

In the next issue we will be back to a full eight pages of PC Clinic and will be looking at the main PC output device, the video monitor, graphics display cards, and the serial and parallel I/O ports.

Transputer Based Si - Construction



Fancy building your own supercomputer or sophisticated graphics engine? Then why not try this versatile single board design from Andy Papageorgiou and Mark Robinson

Back in September 1985 Inmos unveiled the transputer amid a blaze of publicity, promises of unlimited computer power, and cute ray-traced Newton's Cradles on Tomorrow's World. Nine years later and it seems that the transputer has been mostly forgotten: headlines today are dominated by the new Intel processors. Nevertheless, transputers found a niche in highly parallel supercomputers (the Meiko computing surface, for example), graphics processors and research machines, which justified their continued development by Inmos (now owned by SGS-Thomson). The imminent release of the 64bit T9000 proves that the transputer is far from being consigned to computer history.

To allow you to see for yourself what sets the transputer apart from other processors, we present the ETI T225 based single board computer; the first ever project to feature a transputer in a hobbyist magazine. The board provides a good low-cost evaluation system for experimenting with transputers as well as being a useful 16 bit controller card, which can be built for little more than the cost of commercial 8 bit cards. The card was designed for use in robotics, but it is ideal for many "intelligent" control applications involving, for example, image processing or neural networks. The full specification of the card is given in table 1.

The Transputer

The transputer was Inmos' solution to the von-Neumann bottleneck, unfairly named after the computing pioneer John von-Neumann, who first outlined the architecture of the modern microprocessor. In the early days of computing, processing power was limited by crude memory and I/O (the CPU was more likely to be waiting for the right bit to fall out of the mercury delay line than doing real work). Relatively high speed, high capacity core memory and the "glass teletype" changed that, and the computing power became limited by the time taken for the CPU to fetch, decode and operate on instructions - the von-Neumann bottleneck.

Taken on its own, the T225 is a fairly average 16 bit von-Neumann processor. What sets it apart from other processors is the ease with which multiple processors can be connected together using Inmos Links, the asynchronous 20 Mbit per second serial ports which all transputers have on chip. The links provide the hardware to connect large arrays of transputers together very simply and the instruction set provides single instructions to read from, and write to, the links using DMA, with

ingle Board Computer

the minimum of processor overhead. Furthermore, the link protocol remains the same across the entire transputer family allowing any combination of devices to converse easily. Another aid to multiprocessing is the common 5MHz clock frequency used by all transputers and support devices, which is multiplied by an on-chip PLL to the required device clock frequency.

Fantastic developments in microprocessor technology (RISC, pipe-lining and the phenomenally high speed of modern processors) have now widened the von-Neumann bottleneck to the point where memory speed is again the limiting factor; hence the requirement for high-speed cache memory to get the maximum benefit from modern devices. This may be part of the reason why the transputer has been overlooked: the vast majority of computing tasks can be performed with a single processor so why bother with the expense of a parallel system, especially given the extra complication of the software development.

Well, that isn't the full story; if it were, the current design using a single T225 would be no better than a design based around, say, a 68000. It isn't just the multiprocessor capability that sets transputers apart from the 'conventional' processors. The transputer architecture also provides hardware support for multitasking; the ability of a single processor apparently to run several processes (or tasks) concurrently. What actually happens is that the processor runs each process individually for a short time before shelving (descheduling) it and moving on to the next. Obviously, when a process is descheduled (a 'context switch' in the jargon) its current state (the 'context') must be saved somewhere to allow it to be picked up from where it was left off when it is next scheduled.

Any microprocessor can be programmed to multitask. UNIX and Microsoft Windows are testimony to this. However, on conventional processors the overhead associated with context switching can be considerable, and a process must be running to look after the scheduling of other processes. On the transputer, concurrency is handled in hardware with very little overhead, for example a 25MHz T225 can achieve a context switch in less than 800ns. The instruction set contains instructions to simplify the creation and control of concurrent processes. Scheduling of processes is carried out automatically and transparently, a process is descheduled whenever it cannot continue (it may be waiting for data from another process for example) or, when there is more than one active process, these are automatically timesliced.

Processes communicate with each other via a 'channel'; a pre-arranged pair of memory locations into which the communicating processes place their messages. The instruction set includes instructions to create, read from, and write to these channels. Communication between two processes running on separate transputers follows the same protocol, except that one of four 'special' channels associated with the hardware links is used. This means that you can develop code on one (or a few) transputers, and distribute it around several transputers later with very little modification.

Finally, another useful feature is the option to boot from a link. If this mode is selected, after a reset the transputer waits for a boot program to be sent down any of its links. This facility allows code to be sent directly from a host computer, removing the need to repeatedly erase and reprogram EPROMS during debugging. Anyone who has developed code with just an EPROM programmer and eraser will recognise this feature as a godsend.

The PCB has been designed with future proofing in mind. The four links and other control signals have been brought out to a DIN41612 connector which allows a number of cards to be plugged into a backplane for real parallel computing, and/or to expand the number of I/O ports. ETI will continue to publish add ons: a low cost link-based framestore is planned, with some example image processing software and a card containing four transputers (and associated RAM) is in development.

Circuit Description

The full circuit diagram is given in figure 1. IC6c, IC6d and associated components provide the master 5MHz clock for the transputer, IC1. IC4 and IC5 provide 32K 16 bit words of high speed static RAM, IC4 stores the even bytes of the word and IC5 stores the odd bytes. IC3 is the optional ROM; any 28 pin EPROM, EEPROM or NVRAM device can be fitted here. Although the T225 has a 16 bit data bus, the 'byte access' mode is used to permit a single 8 bit ROM to be used. If the BACC pin of the transputer (pin 56) is asserted during an external memory access, the transputer assumes that it is addressing an 8 bit device, and performs two byte-wide accesses. During byte access, the lower half of the data bus (D0-D7) is used for the data and the address line A0 (unused during a normal word access) selects whether the odd or even byte is required. This is the reason why A0 is connected to the ROM but not the RAM. The ROM occupies the upper half of the address map and it can be paged in or out under software control.

If a writable device (EEPROM or NVRAM) is used for IC3, the transputer can write to it as if it were RAM. However, when choosing an EEPROM, make sure that it has an automatic self-timed write cycle generator. This type of EEPROM can be written to with the same timing as RAM, except for the restric-

TABLE 1

Specifications of the card

Processor	25MHz 16 bit T225
RAM	64K High speed static
ROM	up to 32K
Links	4 20Mbit/s serial links
I/O	DIN41612 backplane connector

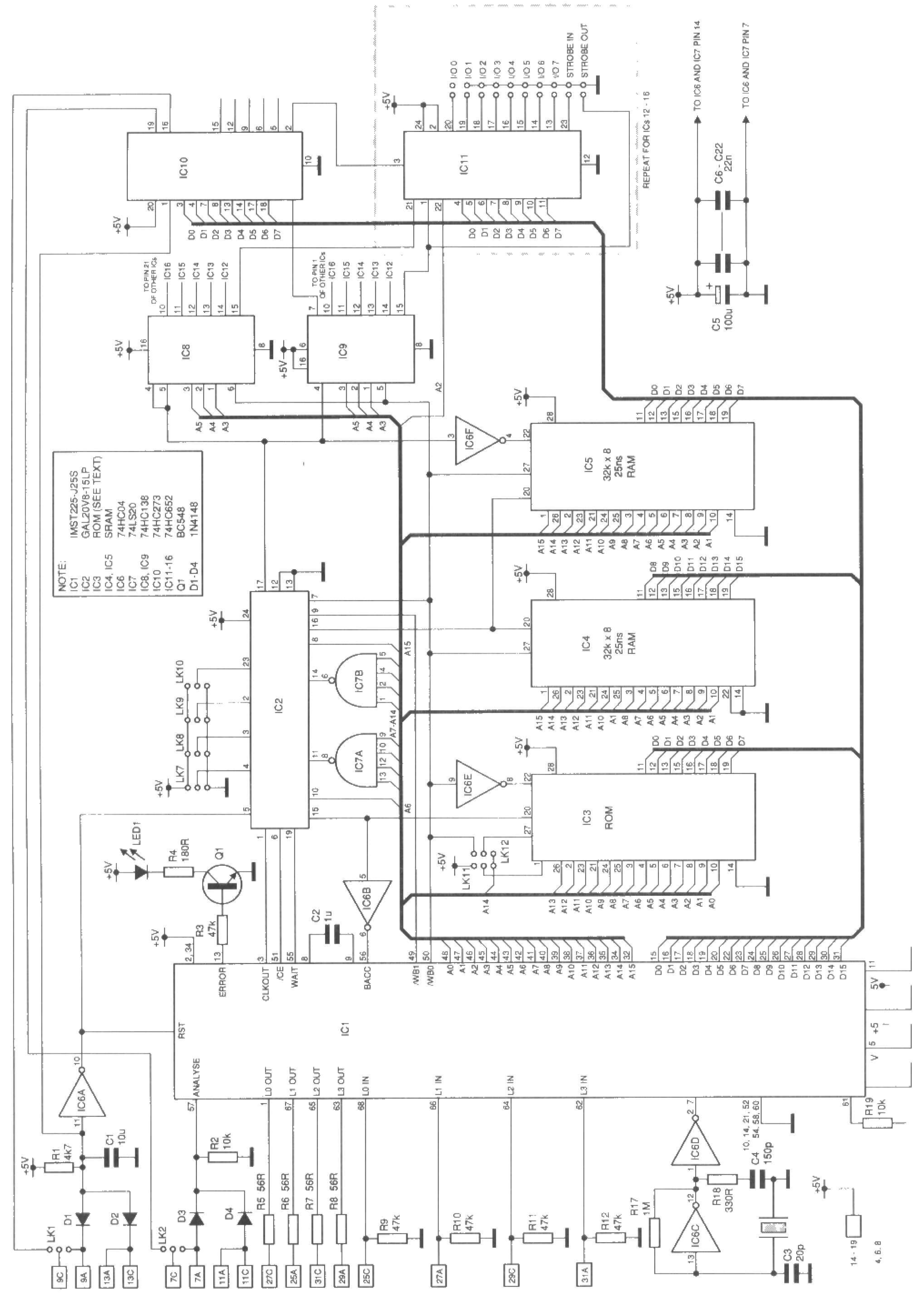


Fig. 1 ETI Transputer Circuit Diagram

tion that there must be a delay of (typically) 5ms between writes. We have tested the board with Excel XLS28C256AP-15 EEPROMS, available from Maplin, but cannot guarantee that other devices will work. The jumpers LK11 and LK12 allow for the slightly different pinout of some ROM devices to be accommodated.

The address decoding and control logic is performed within IC2, a 20V8 GAL. Programmable logic devices tend to be underused in hobbyist projects, probably because device programmers are expensive and not easily available to amateur constructors. For this project, the complexity of the logic means that it would be impractical to design using conventional gates, especially since the timing of most of the signals is very tightly specified. The logic equations are given in listing 1 for anyone who wishes to program their own device, or alternatively pre-programmed devices are available from the authors.

The NAND gates IC7, together with the A6 and A15 lines are used by the GAL to map the I/O space into the upper 128 bytes of memory. These 128 bytes are further decoded into sixteen 8 byte segments (the upper eight of which are echoes of the lower eight) by IC8 and IC9. Read operations are decoded by IC8 and write operations by IC9. IC6f disables the lower RAM when an I/O read is performed to prevent bus contention.

The GAL also handles the ROM paging register and adds the required wait states when the ROM is accessed. Either three or six wait states can be added (selectable with LK9) to cater for ROM devices with speeds of 150ns or faster and 150-300ns respectively. The ROM select line is inverted by IC6b and used to assert the transputer byte access pin.

The I/O ports use the versatile 74HC652 latched bus transceiver chips. These chips are a bit expensive, but the extra versatility is well worth it. When set to input, the port appears as two locations in memory, reading from one returns the data currently on the port, while reading from the other returns the contents of the input latch. Data is put into the latch on the rising edge of the STROBE input, and can still be read when the

PARTS LIST

Resistors

R1	4k7
R2, R19	10k
R3	47k
R4	180R
R5, R6, R7, R8	56R
R9-R16	10k by 8 SIL
R17	1M
R18	330R

Capacitors

C1	10u 16V elect
C2	1u 16V Tantalum
C3	20p ceramic
C4	150p ceramic
C5	100u 16V elect
C6-C22	100n 50V miniature ceramic disk

Semiconductors

Q1	BC548
D1-D4	1N4148
IC1	IMST225-J25S
IC2	GAL20V8A-15LP
IC3	ROM (see text)
IC4, IC5	256Kbit x 8 25ns SRAM
IC6	74HC04
IC7	74LS20
IC8, IC9	74HC138
IC10	74HC273
IC11-IC16	74HC652

Misc.

X1	5MHz crystal
PL1	DIN41642 64AC plug

1 strip 32 x 2 0.1 inch connector strip
1 strip 32 x 1 0.1 inch connector strip
shorting plugs

The following parts are available from the authors. Send a cheque payable to M Robinson to:
Mr M Robinson (ETI)kit), 124 Swanlow Lane,
Winsford, Cheshire CW7 1JA
complete kit (includes everything) - £175.00
PCB - £39
preprogrammed GAL - £10
software disk - £8
all prices include VAT, postage etc. PCBs are made by a batch process, so orders will be accumulated until there's sufficient for a batch so please be patient. They won't cash any cheques until orders are about to be sent out.

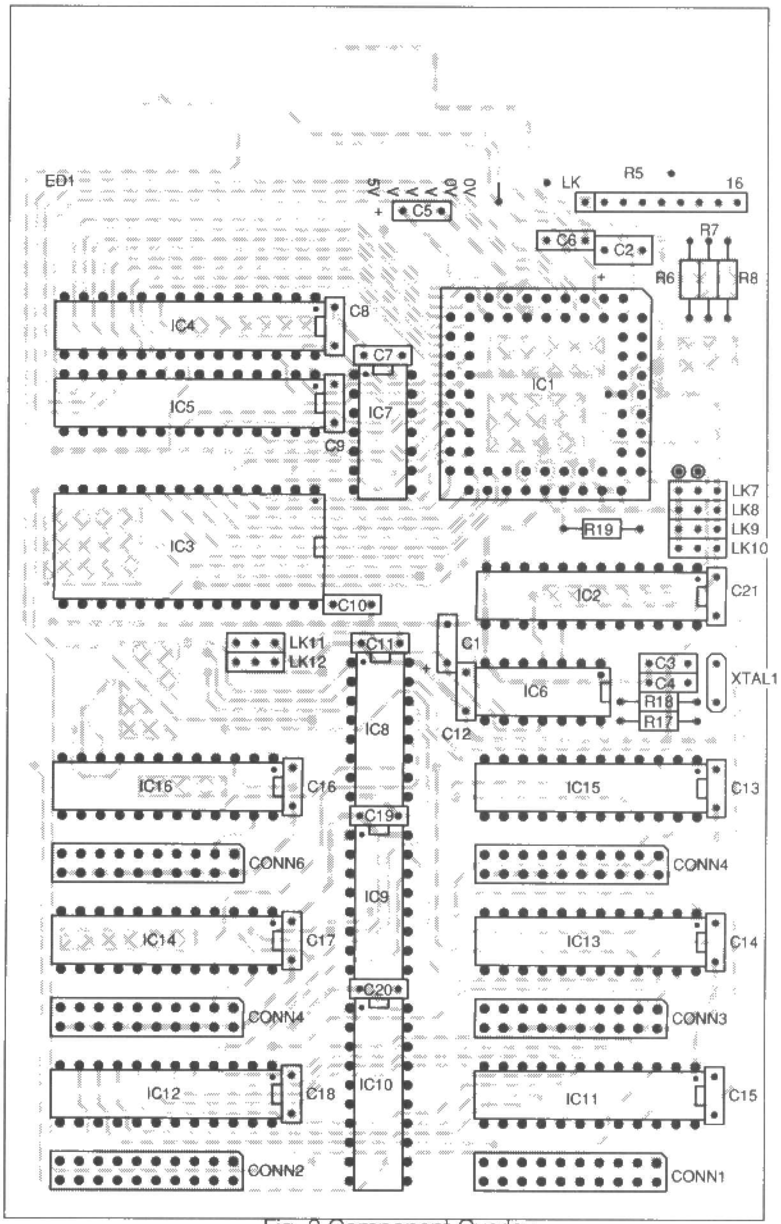


Fig. 2 Component Overlay

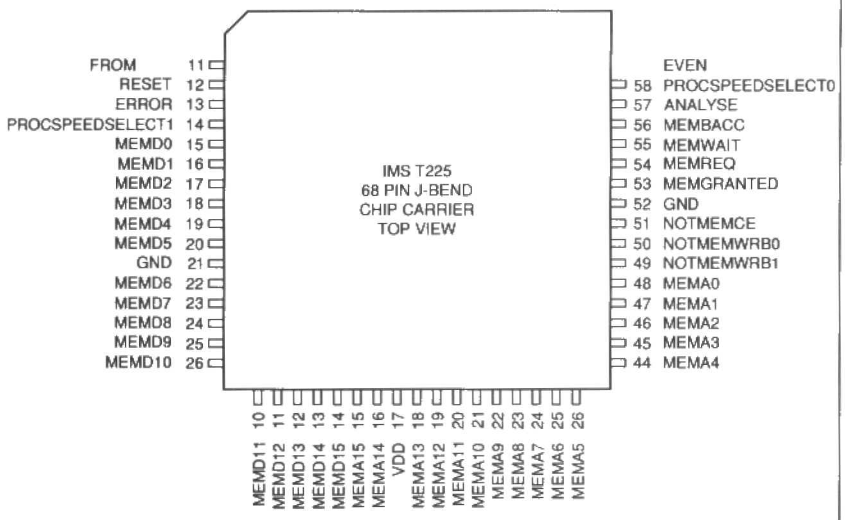


Fig. 3 Pinout of the T225

port is set to output. If the port is written to while it is set to input, the data is put into the output latch, and will be presented to the port when next put into output mode.

The six least significant lines of the latch IC10 are used as the data direction signals for the I/O ports IC11 to IC16. On reset the latch is cleared, which sets all the ports to input to prevent damage to any external devices connected to them. It should be noted though that the ports do not have pull down resistors, so any unused inputs (including the input strobes) must be tied to ground through a 10K resistor. If an entire port is unused it is probably more convenient not to fit the relevant port chip.

The top two outputs of the data direction latch are taken to the backplane, the idea being that in a multiprocessor system this transputer can use these outputs to reset or analyse transputers further down the line. Jumpers LK1 and LK2 can be used to disable this feature.

The transputer error line is buffered by Q1 and used to light LED1. The error signal is asserted whenever an instruction results in an error condition, for example a mathematical overflow. There are also a couple of instructions to turn the error signal on or off, which come in handy when testing the board.

Construction

Construction is relatively straightforward using the double sided, through-hole plated PCB. The board must be through-hole plated because connections need to be made to inaccessible places on the top side.

Make sure you have the PCB the right way up before starting to fit any components. The component side has a small rectangle of crosshatching, which is in the top left hand corner of the component overlay given in figure 2. The PLCC socket is a pain to fit so it's best to put this in first before other components get in the way. Make sure all the pins are roughly straight, place the holder over the holes with the odd corner in the top left position and work the pins into the holes, using a small screwdriver to tease the stubborn pins into place. It is easy for a pin to bend up under the socket during insertion, so check carefully that every hole has a pin in it before soldering the socket in. Don't put the transputer in yet because it will be next to impossible to get it out without a special tool.

Fit the remaining IC sockets next since they provide useful markers when looking where to place other components. It is probably not worth fitting sockets for the cheap 74 series parts, provided you are careful not to overheat them when soldering, and observe static precautions for the HC family devices. If you have trouble finding the proper IC sockets for the bigger skinny DIP parts, the 24 pin sockets can be built from a 16 and 8 pin socket butted together, and the 24 pin sockets from two 14 pin ones. Nearly ever pair of IC pins has a track passing between them so use a 15W soldering iron with a fine bit and be extra careful not to bridge tracks.

There are a number of jumper options provided on the board. These are made using 0.1 inch square pin socket strips and push on jumper links. The same socket strip is used for the I/O port connectors because it forms a cheap plug when used with IDC connectors. This is fine for home use, but for industrial use, or where the board will be subject to vibration, it is better to fit latching IDC header plugs.

Fit the remaining components in height order, but leave the semiconductors until last, especially the static sensitive ones. Check carefully that each component is in the right holes before soldering, it is all too easy to put a component into a via-hole. If you do have to remove a component, clean up as much solder as possible with braid or a solder sucker, but do not overheat the board or you may pull the plating out of the hole. When you have finished double and triple check the board for short circuits and bad joints.

Testing

Do not fix any of the socketed chips yet. Apply power to the board and check that +5V and 0V appears on the sockets at the right places. Check that a 5MHz square wave is present at pin 7 of the PLCC socket (see figure 3 for the pinout). If you can't find the clock on the PLCC socket, check at pin 12 of IC6 If it isn't there, check the circuitry around IC6c. Check also that all the outputs of IC10 are set low which ensures that the power on reset circuit R1, C1 and IC6a are functioning.

If everything seems OK, turn off the power and insert all the ICs into their sockets. Place a finger on the transputer, the GAL and as many other chips as possible and turn on the power. If nothing gets hot or shows signs of distress breathe a huge sigh of relief, otherwise turn off fast and check your work.

That's about as much testing that we can do without some software, but that will have to wait until next month. We will also provide a Link adapter circuit that uses an 8255 based PC I/O card fitted to an IBM compatible PC, so you might like to buy or build a card if you don't already have one. We used the Maplin kit (stock number LP12N), and ETI's card published in November 1993 is compatible with this. Any 8255 based card should work but the connector pinouts may be different. Testing and software development may be carried out without the link adapter, but it is a tedious process.

LISTING 1

```
module NEWT_PAL
options '-document long'
title 'BOARD LOGIC - ajp'
NEWTic device 'P20V8';

proclk romspeed, page_act, paged_at_boot      pin     1, 2, 3, 4;
reset, ce, rw0, al5, rwl, a6, anda, andb      pin     5, 6, 7, 8, 9, 10, 11, 14;
rom, ram, io, paged, wait                     pin     15, 16, 17, 18, 19;
count0, count1, count2, writable              pin     20, 21, 22, 23;

equations

            paged       =       (reset & paged_at_boot)
                                #(!a15 & !anda & !andb & rw0 & !rwl & !a6 & !ce)
                                #(!reset & !count0 & paged)
                                #(!reset & !count1 & paged)
                                #(!reset & !count2 & paged)
                                #(ce & paged_at_boot & paged);

            count0      =       (!count0 & wait & !reset)
                                #(!a15 & !anda & !andb & rw0 & !rw1 & a6 & !ce);

            Count1      =       (!count1 & count0 & wait & !reset)
                                #(count1 & !count0 & wait & !reset)
                                #(!a15 & !anda & !andb & rw0 & !rw1 & a6 & !ce);

            count2      =       (!count2 & count1 & count0 & wait & !reset)
                                #(count2 & !count0 & wait & !reset)
                                #(count2 & !count1 & wait & !reset)
                                #(!a15 & !anda & !andb & rw0 & !rw1 & a6 & !ce);

            io          =       ! (!a15 & !anda & !andb & !ce & paged);

            rom         =       ( (!a15 & !anda & !andb & paged)
                                #a15
                                #ce
                                #(!rw0 & writable)
                                #(!a15 & !anda & !andb & rw0 & !rw1)
                                #(!a15 & paged & page_act));

            ram         =       ! ( (!a15 & !anda & !andb & !ce & paged)
                                #(a15 & !ce)
                                #(!a15 & !paged & !rw0 & !writable & !ce)
                                #(!a15 & paged & !page_act & !rw0 & !writable &
                                !ce)
                                #(!a15 & paged & !page_act & !ce));

            wait        =       ! ( (!a15 & !anda & !andb & paged & count0)
                                #a15
                                #(!a15 & paged & page_act)
                                #(!rw0 & writable)
                                #(!a15 & !anda & !andb & rw0 & !rw1 & count0)
                                #(count1 & count2 & romspeed)
                                #(count0 & count1 & !romspeed));

end NEWT_PAL
```

A PROJECT USING THE FORTH SBC

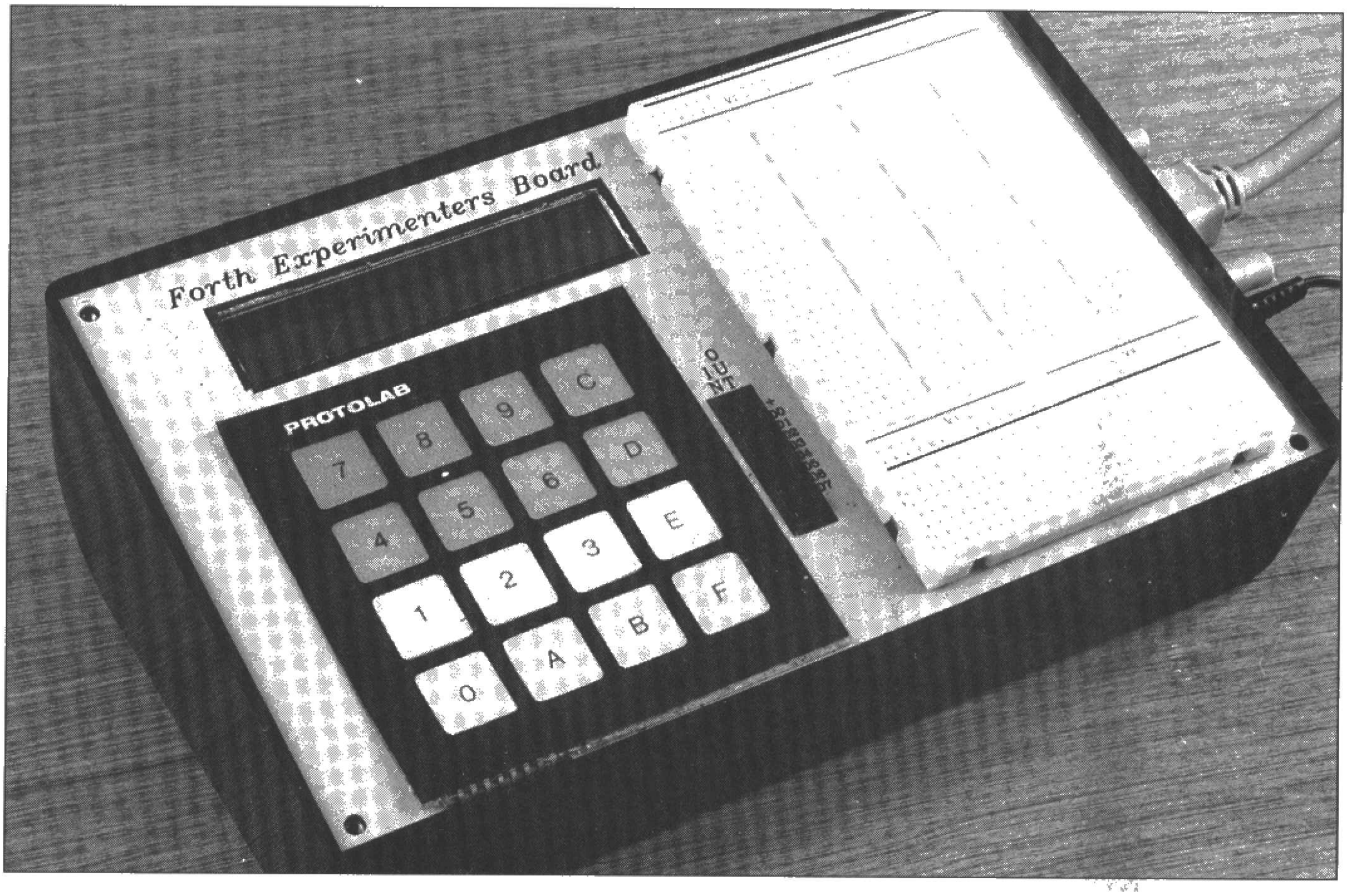
The ETI Forth Experimenter's Computer is used by M. Trueblood to decode the 60khz time transmission broadcast by the National Physical Laboratory in Rugby

As a follow-up to the Forth SBC project, a use has to be made of the available processing power and I-O facilities. Forth being especially suitable for the control of peripherals and input-output signal processing, the proposed project features the F-SBC and an input peripheral. The device in question is a radio capable of receiving the National Physical Laboratory 60KHz time transmission from Rugby. This signal can be received in most, if not all, parts of the U.K. As the main objective of this article concerns the programming, using Forth, of the F-SBC, no construction details of the radio equipment have been included. There are at least two kits on the market of suitable receivers, one by Cirkit as used by the author, and one by Maplin.

The time transmissions are maintained to a high degree of accuracy, being derived from a caesium resonator and so as to be useful to a greater number of potential users, the encoding of the transmitted radio signal has been kept simple.

The coding used is digital, being binary coded decimal, and over a period of one minute there are two data packets sent. Each, when decoded, provide the time. One packet, known as the 'fast code', is transmitted during the first second of any minute. For the following 51 seconds, a 'slow code' is sent and for the remaining 8 seconds a synchronising pattern is transmitted. The modulation method used is switched carrier, for the fast code a pulse present signals a 'one bit' and for the slow code it is the pulse width that signals a 'one' present or a 'zero'. The diagram shows the format of the signal.

It can be seen that the pulse width used to encode the fast code is 10mS and for the slow code 900/800mS. It is the slow



code that is to be decoded, as it is somewhat easier to receive.

Further information about time transmissions should be available from the National Physical Laboratory, Teddington, Middlesex.

The output signal from the receiver is at a TTL logic level and should be connected to one of the input port pins of the F-SBC. I have chosen data bit 0 of input port 6, shown on the F-SBC circuit diagram as IC12 pin 2. The cable used for the connection should be screened, and a 0Volt line connected between the radio and computer. In the author's location, the radio signal pick-up improved when it was positioned near a window and as far from the computer as possible.The best reception was in daylight hours.

As the complete Forth SMC project has not yet been published, the Forth words used should be part of the implementation, being part of the standard vocabulary. As the system used to develop the program did not allow vast amounts of annotation, the program listing is provided at the end and each words function will be described here. But first, a resume of the basic structure.

What needs to be done ?

Read the raw data into the computer, at the lowest level each pulse, one a second. When at least one full minute's worth of data has been collected, decode it first to zero's and ones then into the date and time. To be sure of capturing a complete data set 120 samples are taken. Finally, display the result.

The above scenario is true but a little basic. For instance, it would be more user-friendly if the system didn't loop indefinitely when the position of the radio was such that a garbled signal was being received. Similarly, if no input signal were present, an abort route should be provided. As the data is pulse width modulation, the program is effectively timing the width of incoming pulses by counting; it would be nice if the program would run successfully on any Forth system irrespective of its speed. Both these points are covered. Like all programs, the actual primary function is only a part of the total. As well as catering for the expected data, the unexpected has to be allowed for. The fact that it is unexpected is a major reason for computer crashes. Doing this in real time is an even more difficult task; this program is not a real time implementation. The data is captured, processed and the result displayed, in that order. No attempt has been made to do all three activities concurrently. A point that isn't covered though is the checking for valid results, an equally important part of the total program; this has been left for the reader. Simply, a check for a valid year.

Description of the Words.

First define the variable data space.

RDP6D0

Read data from port 6 data bit 0 and invert if required. As the F-SBC project has not yet been concluded, this code has been tested using another system and the polarity of input signals to produce a logic '1' did not require the inversion. If the F-SBC requires such an inversion, then the AND at the end of this definition should be replaced with a XOR.

So that spurious 'spikes' in the received data stream are not picked up as a data pulse, the input level is sampled and after a delay sampled a second time, both samples have to be positive to indicate a true signal. This is an area for experimentation, changing the timing loop to achieve consistent results.

RDPLS

Read one pulse and count the width. First wait for a pulse to be present and then count on stack for its duration. This will give an invalid result if scan starts in other than a gap between pulses. However, the required input data consists of 43 consecutive pulses and the program reads a sequence of 120 so as to include one full sequence. The fact that the first pulse may be incorrectly decoded doesn't matter as processing proceeds from the most recently acquired pulse and the first should never be used. Once the first pulse has ended, the program will be scanning in the following gap looking for the next pulse and so, from here on, will start the count sequence from the leading edge.

ZINDEX

Reset to zero the index used in accessing the data buffer.

INDEX1+

Add 1 to the index variable.

RDATA

Reads 120 pulses onto the stack. The word picks the data off the stack, transferring into the data area variable BUFFER, processing it into '0' or '1' depending on whether the value is greater or less than the computed 'critical value' held in variable RADIX. At this stage the most recent read data will be in the start of the buffer, i.e. buffer index = 0 = B(I) = last pulse received.

DEC-INDEX

Subtract 1 from the INDEX variable

CHK-INDEX

Check for an out of bounds INDEX value. This is used as an indication that no valid data has been received or, more specifically, no sync pattern.

RD-BUF

Pick-up data from the buffer and update the INDEX ready for the next value.

FIND-SYNC

As can be seen from the signal chart, a synchronisation pattern of '01111110' will be transmitted during the last 8 seconds of every minute. The program reads a sufficient amount of data to include the sync pattern and at least a full minute's worth of data. It was considered to be a more clean-cut method of decoding to search for the sync pattern and then step back through the data from the 52nd second to the 18th second. The information of interest following on from the last sync bit.

On exit, the INDEX variable holds an index into the data buffer where the first valid data bit is stored i.e. this will be the 52nd second of that particular minute. An error exists if the INDEX > 120, indicating no sync pattern, is found.

RX-TIME

Read the raw data, process it into '0' or '1'.

Search for a sync pattern, provide an escape by pressing any key if the program is looping. This shouldn't happen as the program checks that a signal is being received before getting this far. But conditions may change.

C-ONETEN

Convert the top three stack items, that represent BCD, into a decimal value.

C-MIN

Calculate the value of minutes(decimal) from the seven BCD digits located in the buffer the first digit pointed to by the value of INDEX.

C-HOUR
Calculate the value of hours(decimal) from the six BCD digits located in the buffer the first digit pointed to by the value of INDEX.

C-DOW
Calculate the value of the day of week (decimal) from the three BCD digits located in the buffer the first digit pointed to by the value of INDEX. The day is not displayed by the program.

C-DAY
Calculate the value of the day(decimal) of the month from the six BCD digits located in the buffer the first digit pointed to by the value of INDEX.

C-MONTH
Calculate the value of the month(decimal) from the five BCD digits located in the buffer the first digit pointed to by the value of INDEX.

C-YEAR
Calculate the value of year(decimal) from the eight BCD digits located in the buffer the first digit pointed to by the value of INDEX.

CALC-TIME
Calculate the date and time from the '0' and '1' data using the C- words.

DP-DTIME
Display the date and time previously calculated and now held in the respective variables.

CAL-RADIX
So that the system's speed is not a factor in using the program, it calculates a critical pulse width. The simple formulae of (0.9 X MPW) were MPW is the maximum counter value from a sample of 120 pulses. Pulses greater are deemed to be a logic one and those less than critical are logic zeros. Also checks for the presents of a signal.

RUGBY
This is the top most word, to run the program type RUGBY. Possible output messages:-

Unable to receive time, check radio position'

Meaning, no pulses have been detected

'Radix set= xxx'

Meaning, a pulsing signal has been detected and the average calculated as xxx.

'Input data is not pulsing'

Meaning, port 6 data bit 0 is at steady '0' or '1'

'No sync'

Meaning, after scanning through the data buffer no sync pattern was found

'Index= xxx'

Meaning, position within the buffer that the sync pattern was found.

SIGNAL TIMING CHART

SECONDS	VALUE(dec)	NAME
1		FAST CODE
2		D.U.T. SIGNAL
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		LEAP SECOND
18	80	YEAR
19	40	YEAR
20	20	YEAR
21	10	YEAR
22	8	YEAR
23	4	YEAR
24	2	YEAR
25	1	YEAR
26	10	MONTH
27	8	MONTH
28	4	MONTH
29	2	MONTH
30	1	MONTH
31	20	DAY
32	10	DAY
33	8	DAY
34	4	DAY
35	2	DAY
36	1	DAY
37	4	DAY OF WEEK
38	2	DAY OF WEEK
39	1	DAY OF WEEK
40	20	HOUR
41	10	HOUR
42	8	HOUR
43	4	HOUR
44	2	HOUR
45	1	HOUR
46	4	0MINUTE
47	20	MINUTE
48	10	MINUTE
49	8	MINUTE
50	4	MINUTE
51	2	MINUTE
52	1	MINUTE
53		SYNC BIT = 0
54		SYNC BIT = 1
55		SYNC BIT = 1
56		SYNC BIT = 1
57		SYNC BIT = 1
58		SYNC BIT = 1
59		SYNC BIT = 1
60		SYNC BIT = 0

WORD USAGE

```
RUGBY....CAL-RADIX
         RX-TIME...............................RDATA....................RDPLS
         CALC-TIME.......C-MIN                 FIND-SYNC
         DP-DTIME        C-HOUR
                          C-DOW
                          C-DAY
                          C-MONTH
```

DATA FLOW

```
SIGNAL >> RDPLS >>to>> STACK  >>>>  RDATA  >>to>>  BUFFER  >>  FIND-SYNC  >>  CALC-TIME  >>  DP-DTIME

          count       120 pulses  process                       '01111110'    calculate &     display
          width                   into                                        set variables    date
                                  '0' or '1'                                                   time
```

```
( FORTH program listing by M.Trueblood )

VARIABLE BUFFER 121 ALLOT
VARIABLE RADIX
VARIABLE INDEX
VARIABLE MINUTE
VARIABLE DAYOW
VARIABLE DAY
VARIABLE MONTH
VARIABLE YEAR

( READ PORT 6 BIT 0 )

: RDP6D0
    6 IN
    100 0 DO LOOP
    6 IN
    AND
    1 AND
;

( READ ONE PULSE )

: RDPLS
   BEGIN
        RDP6D0 1 =
   UNTIL
0
   BEGIN
        RDP6D0 1 =
   WHILE
        1 +
   REPEAT
;

( PRINT BUFFER  ** DIAGNOSTIC WORD TO DISPLAY 120
BYTES FROM BUFFER )

: PBUF
   120 0 DO
      BUFFER I + C@ .
   LOOP
;

( ZEROISE INDEX )

: ZINDEX
   0 INDEX !
;

( ADD ONE TO THE INDEX )

: INDEX1+
   1 INDEX +!
;

( READ THE PULSES )

: RDATA
   ZINDEX
   120 0 DO
         RDPLS
      LOOP
   120 0 DO
         DUP 100 <
           IF
              DROP
           ELSE
            RADIX @ <
               IF
                  1 BUFFER INDEX @ + C!
               ELSE
                  0 BUFFER INDEX @ + C!
               ENDIF
             INDEX1+
           ENDIF
        LOOP
;
```

```
( SUBTRACT ONE FROM INDEX )
: DEC-INDEX
           INDEX @ 1 - INDEX !
;

( CHECK FOR OUT OF BOUNDS )
: CHK-INDEX
           INDEX @ 120 >
;

: RD-BUF
           BUFFER INDEX @ + C@ INDEX1+
;

( SEARCH BUFFER FOR SYNC PATTERN 01111110 )

: FIND-SYNC
           ZINDEX
BEGIN
    BEGIN
         BEGIN
             RD-BUF 0 =
         UNTIL
         0 6 0 DO
                 RD-BUF +
               LOOP
         6 = CHK-INDEX OR 0 =
    WHILE
         6 0 DO
               DEC-INDEX
             LOOP
    REPEAT
    RD-BUF 0 = CHK-INDEX OR
UNTIL

CHK-INDEX DUP IF ." NO SYNC "
              ELSE ." INDEX=" INDEX @ .
              ENDIF
0 =
;

( RECEIVE TIME CODE SIGNAL THEN LOOK FOR SYNC
PATTERN )

: RX-TIME
         RDATA
         BEGIN
              FIND-SYNC ?TERM OR 0 =
         WHILE
              RDATA
         REPEAT
;

( READ PULSE COUNT LENGTH FROM BUFFER )

: RD-BUF
        BUFFER INDEX @ + C@ 1 INDEX +!
;

: C-ONETEN
          10 * + SWAP 8 * + SWAP
           4 * + SWAP 2 * + SWAP
           1 * +
;

( CALC MINUTE )

: C-MIN
      7 0 DO RD-BUF LOOP
      40 * SWAP 20 * + SWAP
      C-ONETEN DUP 59 < IF 1 + ENDIF
      MINUTE !
;

( CALCULATE HOUR )

: C-HOUR
       6 0 DO RD-BUF LOOP
       20 * SWAP C-ONETEN
       HOUR !
;

( CALCULATE DAY OF WEEK )

: C-DOW
      3 0 DO RD-BUF LOOP
      4 * SWAP 2 * + SWAP 1 * +
      DAYOW !
;

( CALCULATE DAY )

: C-DAY
      6 0 DO RD-BUF LOOP
      20 * SWAP C-ONETEN
      DAY !
;

( CALCULATE MONTH )

: C-MONTH
        5 0 DO RD-BUF LOOP
        0 SWAP C-ONETEN
        MONTH !
;

( CALCULATE YEAR )

: C-YEAR
       8 0 DO RD-BUF LOOP
       80 * SWAP 40 * + SWAP
       20 * + SWAP C-ONETEN
       YEAR !
;

( CALCULATE THE DATE AND TIME )

: CALC-TIME
          C-MIN C-HOUR C-DOW C-DAY C-MONTH C-
YEAR
;

( DISPLAY DATE AND TIME )

: DP-DTIME
         CR
         ." TODAYS DATE IS "
        DAY @ . ." /"
        MONTH @ . ." /"
        YEAR @ . ." "
        CR
        ." THE TIME IS "
        HOUR @ . ." :"
        MINUTE @ . CR
;
( CAL-RADIX SETS THE VALUE OF THE AVERAGE PULSE
WIDTH, USED)
( TO DETERMINE IF ONE OR ZERO )

: CAL-RADIX
         0
         1000 0 DO
                   RDP6D0 1 = IF 1+ ENDIF
                 LOOP
         1000 0 DO
                   RDP6D0 1 = IF 1+ ENDIF
                 LOOP
   DUP 1000 = SWAP 0 = OR IF ." INPUT PORT 6 BIT
0 IS NOT PULSING "
      0
                 ELSE
                 120 0 DO RDPLS LOOP
                  119 0 DO MAX LOOP
                  DUP 10 / -
                  DUP ." RADIX SET= " .
                  RADIX !
                  -1
              ENDIF
;
( READ TIME TRANSMISSION AND DISPLAY DECODED DATA
)
: RUGBY
      CR
      CAL-RADIX IF
                 RX-TIME
                 CALC-TIME
                 DP-DTIME
                ELSE
                 CR   ." UNABLE TO RECEIVE TIME,
CHECK RADIO POSITION "
                ENDIF
;
```

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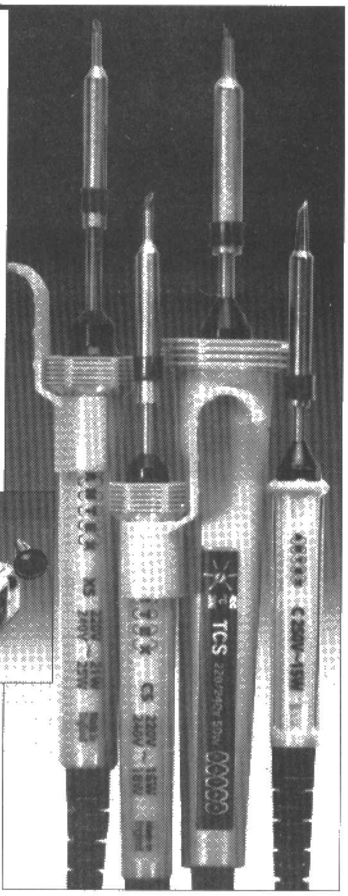

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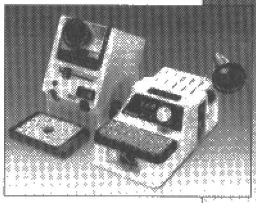

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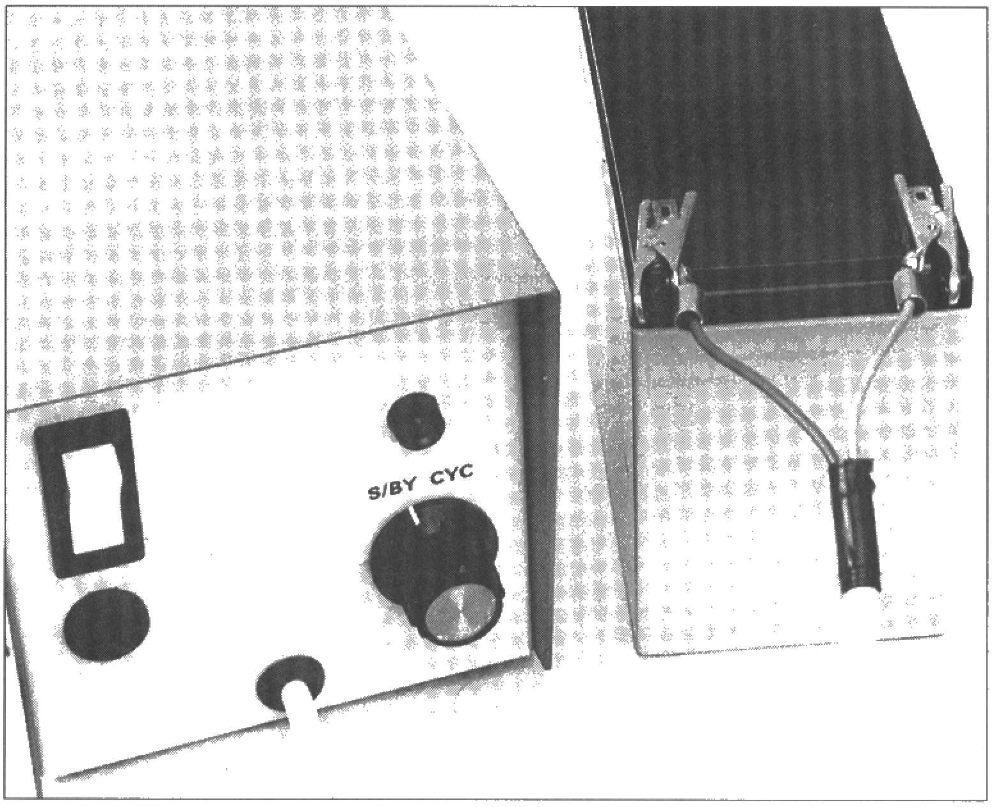
12V Lead-Acid Battery Charger

Battery power can be very useful. Terry Balbirnie shows how to build a handy constant-voltage charger.

Lead acid batteries may be charged in one of two modes - so called, standby (sometimes called floating) and cyclic. In standby use, the battery may be connected to the charger continuously, a small 'trickle' current making up for losses and keeping the battery in good condition. It will only be discharged occasionally, such as when used as the back-up battery in a burglar alarm system. Under standby conditions, the life of a battery should be at least 5 years.

In cyclic use, the battery is regularly charged and discharged and it is thought that most readers will wish to use it this way. The life of a battery in cyclic applications is less than when used in standby mode and depends largely on how deeply it is discharged. If this is only, say,



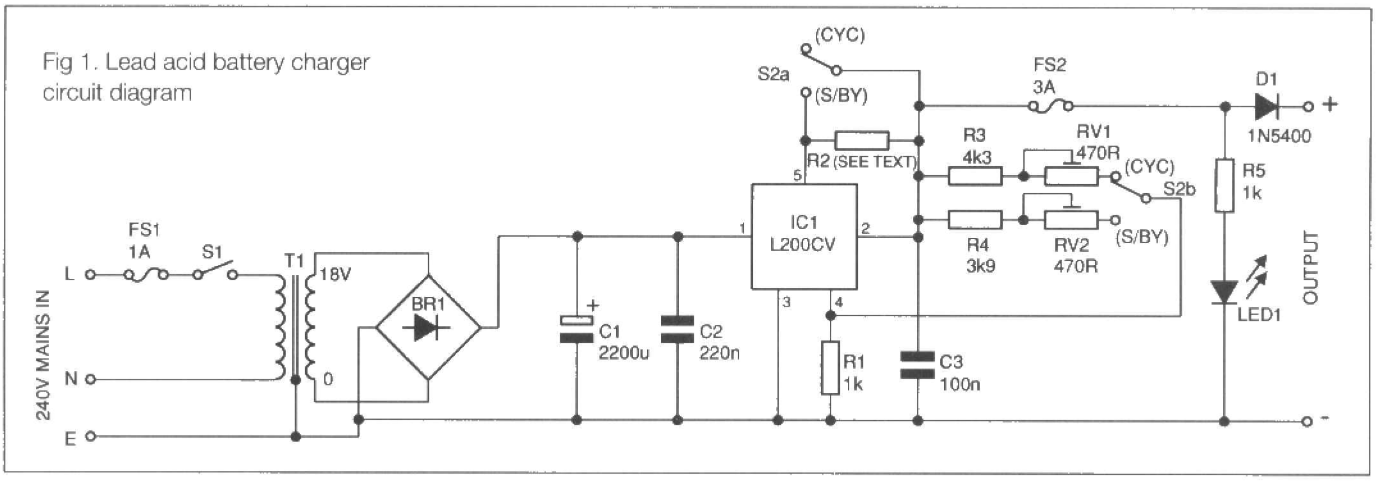


Fig 1. Lead acid battery charger circuit diagram

30% some 1000 charge/discharge cycles may be obtained. After that, there will be an increasing loss in capacity up to the end of the service life. If the battery is fully discharged each time, only 100 to 200 cycles may be expected. Most small lead-acid batteries will tolerate cyclic use well, although those designated cyclic are even better. For a large capacity, a 'leisure' battery such as the Exide Portapower should be used. A standard car battery is designed for near-floating mode and would not make a good choice. This charger can be used for either standby or cyclic charging, with a switch on the front panel selecting the mode.

The maximum current delivered by this unit is only 2A, which makes it simple and inexpensive to construct. A battery of up to 8Ah capacity will take 6 to 8 hours to charge. Large capacity batteries will take much longer but this will not be a disadvantage if the unit is mostly used to top up the existing charge.

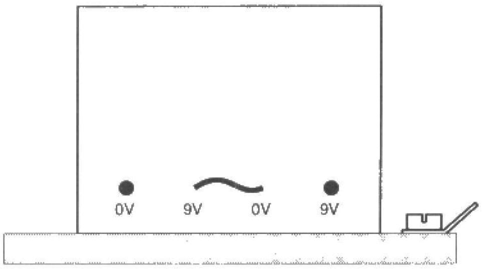


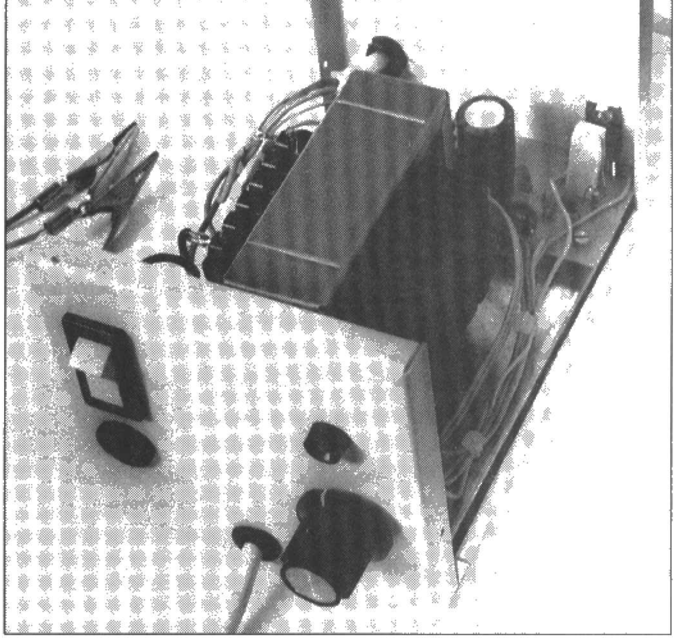
Fig 3. Twin 9v secondary windings connected in series

Constant Voltage

A 12V lead-acid battery does not have a constant terminal voltage 12V is only its nominal value. When fully charged, it rises to over 13V and when discharged falls below 11V. When the terminal voltage drops much below this, the battery is said to be 'deep discharged'. Serious sulphation of the plates occurs and the battery may never recover its capacity when charged. This is why regular topping up of charge is always a good idea.

Charging this type of battery is best effected by using a constant voltage source and this is how the present circuit works. The output will be set a little higher than the full-charge voltage and the excess voltage then drives current through the battery and charges it. As full capacity is approached, the excess voltage falls and the charging current drops. Eventually, this becomes a very small trickle.

There will be a maximum charging current quoted for any given battery. In standby mode, this will be higher than for cyclic use. With batteries above 1Ah (practically all batteries), a 2A standby limit is acceptable (i.e. the maximum output from the charger). For cyclic mode, the current limit will be set using a resistor (R2) on the PCB to a figure appropriate to the battery



being used. A battery having a capacity greater than about 8Ah does not need this resistor, since it is acceptable to use a charge rate of 2A or more. Table 1 lists some typical cyclic charging currents for various capacity batteries and the nearest listed value of resistor R2 needed to provide this. Note that some batteries will tolerate up to double this current, so it is a good idea to consult the manufacturer's data and select R2 to maximise the charge rate.

Circuit Description

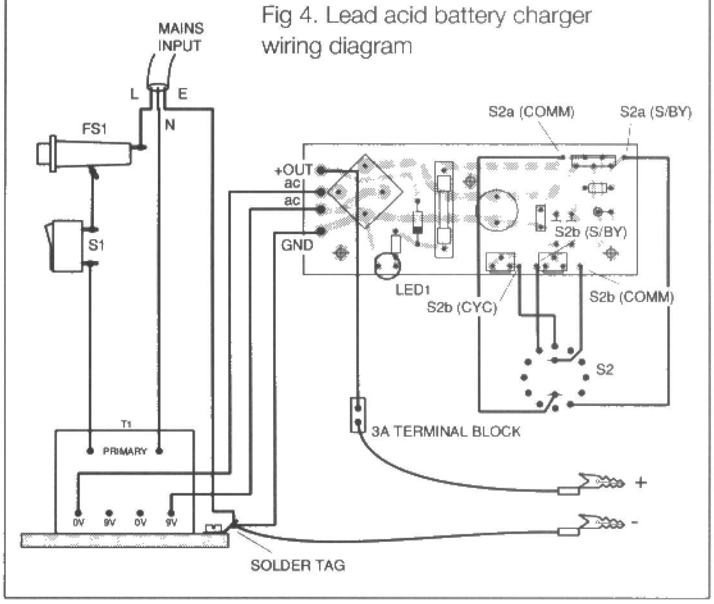


Fig 4. Lead acid battery charger wiring diagram

Figure 1 shows the complete circuit for the Lead Acid Charger. Mains transformer T1 together with bridge rectifier BR1 and smoothing capacitor C1 provide a nominal 24V supply. This is applied to the input, pin 1, of voltage and current regulator, IC1. The output voltage provided at pin 5 is determined by the resistance connected between pins 2 and 4 in conjunction with resistor R1. With R1 fixed in value, the voltage is determined by either R3 and RV1 or R4 and RV2 according to the position of S2 pole b. RV1 will be adjusted to provide a value of 14.6V (cyclic) and RV2 to 13.6V (standby). These are average figures as recommended by the manufacturers of lead-

Table 1

Capacity (Ah)	Suggested cyclic current	R2	R2 min power rating (W)
1.2	0.33A	1.5	0.25
2	0.5A	1.0	0.6
3	0.75A	0.68	0.6
4	1A	0.47	0.6
6	1.5A	0.33	1
8	2A	(omitted) -	(and above)

acid batteries. Preset potentiometers RV1 and RV2 allow an adjustment of about 0.5V on each side of the nominally 'correct' value, to take account of component tolerances.

With switch S2 set for cyclic use, pole a allows current-limiting resistor R2 to be connected between IC1 pin 2 (limiting pin) and pin 5 (output). With S2 set for standby mode the resistor is bypassed. IC1 now imposes its internally-set current limit of 2A approximately.

LED1, in conjunction with current-limiting resistor R5, glows while the charger is switched on, provided that fuse FS2 is intact and the output leads are not short-circuited. This fuse should never fail and is only provided as a precaution in the event of some catastrophic failure. Diode D1 is necessary to prevent the battery draining back through the regulator if the mains supply is switched off.

Construction

Construction of the 12V Lead Acid Battery Charger is based on a single-sided PCB. Figure 2 shows the topside details (parts placement diagram). Refer to Table 1 (and the manufacturer's data) to select the appropriate value and power rating of R2. Where a cyclic current of 2A is being used, R2 is omitted and IC1 pin 5 connected to pin 2 using a link wire on the PCB, soldered between the points marked S2a (comm) and S2a (s/by). S2a is then unconnected and only S2b used. Low value resistors for R2 position are often only available in a higher (3W) power rating. This does not matter, but such a resistor is unnecessarily large. However, sufficient space has been left on the PCB to accommodate one if necessary (see photograph).

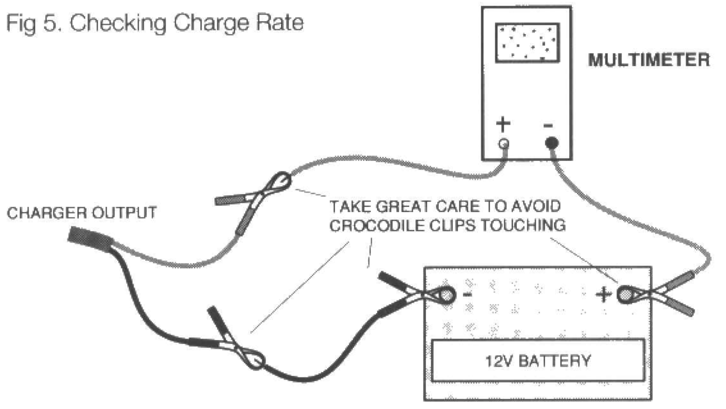


Fig 5. Checking Charge Rate

Prepare the board by drilling the three fixing holes in the positions shown. Drill the component holes and add the soldered parts in the following order. Firstly fuseholder FS2, then all resistors (including the presets) and capacitors (take care over the polarity of C1). Follow with the bridge rectifier and diode D1 (again, taking care over the polarity of these components). Spread IC1 pins to fit the holes in the PCB and solder it into position using minimum heat from the soldering iron. Solder 20cm pieces of stranded connecting wire to the pads marked a.c., gnd, + out, LED1 (2 off), and those for the switch connections (5 off). Use different coloured wires to reduce the chances of errors. Adjust the wipers of RV1 and RV2 to approximately mid-track position.

Before mounting the internal components, adjust the rotary switch to provide only two positions. This is done by removing the large securing nut and the tab washer beneath. This will reveal a circle of small holes. The tab washer should be replaced in its new position to provide the two positions required. Trial and error will soon find the correct location. Replace the large nut. Cut the spindle to a length suitable for the control knob. Do this by gripping the spindle (not the body) in a small vice. Support the switch body by hand and gently cut the spindle to size using a sharp hacksaw. If the transformer is of the type having twin 9V secondary windings, connect them in series as shown in Figure 3.

Note that an aluminium case of the size stated in the parts list (or larger) must be used. This is because IC1 becomes hot in use and the metalwork is needed to act as a heat sink. If it has no ventilation holes, it will be necessary to make some because the transformer becomes warm. If the inside of the box is painted, the paint must be scraped off in the area beneath the IC. This will allow efficient heat transfer. If the specified enclosure is used, the chassis should be drilled for transformer mounting. If a plain box is used, the transformer is simply mounted on the base. Use one of the transformer fixings to attach the solder tag or drill a hole nearby and use a small nut bolt and washer. This must be secure since it is used to earth the case and transformer and is an essential safety requirement. Drill holes to correspond with those in the circuit panel - depending on the type of box, only two of them may be available and this is satisfactory.

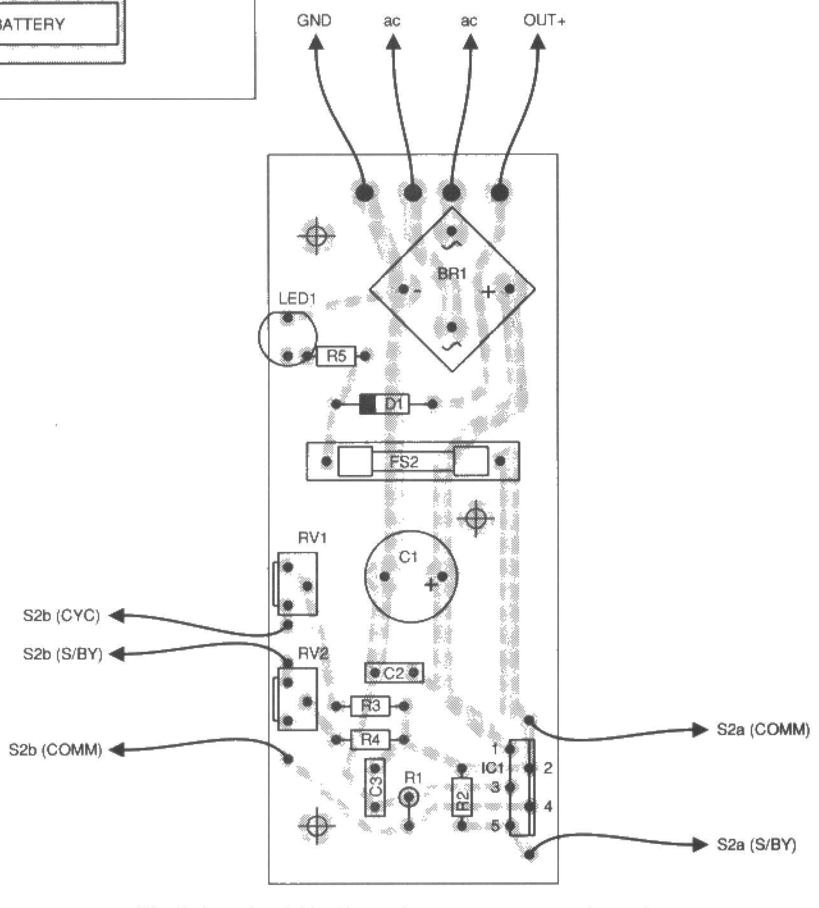


Fig 2. Lead acid battery charger component overlay

Mount the circuit panel temporarily on stand-off insulators then mark the position of the hole in IC1 tab on the rear panel. Remove the circuit board again before drilling this hole. Make holes in the front panel of the box for the switches, LED and fuse holder FS1. Drill the hole for the output lead and fit this with a rubber grommet (see photograph). Drill one in the back for entry of the mains lead - this must be large enough to accommodate the strain relief bush which will prevent the wire pulling free in service which could be dangerous. Attach the circuit panel and chassis (if the box is of this type). Tighten all bolts securely, including the one in IC1 tab. Note that IC1 pins must not end up under strain or they are likely to break off in service. Referring to Figure 4, mount the remaining components and complete the internal wiring. Grouping the wires using small cable ties will keep everything neat and tidy.

Make up the mains lead using 3A three-core wire. Note that this must be secured using a proper strain relief bush - makeshift methods are not satisfactory. If the plug is of the UK fused type, fit a 2 or 3A fuse. Solder the mains wires to the transformer primary, fuseholder and on-off switch as shown in Figure 4, making certain they are secure. The earth wire must be soldered to the solder tag. Make a cardboard shield so that it is absolutely impossible to touch any mains connection when the lid of the case is removed. This shield was removed for the photograph.

Make up the output lead using 3A twin wire, red for positive and black for negative. Fit the ends with small crocodile clips and pass the other end of the wire through the rubber grommet. The negative wire should be attached to the solder tag and the positive one connected to the wire already leading from the circuit panel (+ out). Use a single piece of 2A or 3A screw terminal block to make the connection, making sure that the output lead cannot pull free by securing a strong cable tie around it or by using a piece of tightly-tied string. Insert a 1A ceramic mains fuse in FS1 fuseholder and a 2.5 or 3A glass one in FS2. Attach the output wires to the spare 1kW resistor mentioned in the parts list. This is necessary to load D1 and is particularly important if a high impedance digital meter is being used for testing. Without it, the output voltage readings will be on the high side. Leave the lid removed for the moment.

Testing

Keeping the crocodile clips separated, plug the unit in and switch on. The LED should light. Adjust the multitester to a suitable DC voltage range and apply the probes to the crocodile clips (without disturbing the 1kW resistor). The reading should be about 13-16V for either setting of S2. Carefully adjust RV1 to provide 14.6V then similarly adjust RV2 to provide 13.6V. It may be necessary to make a short trimming tool to do this easily. With the adjustment complete, switch off the mains and attach the lid of the box.

Apply a load (such as a 12V bulb) to the battery and leave it so that it is substantially discharged (a terminal voltage of not less than 11V). Adjust the multitester to a suitable DC current range which can cover at least up to 3A. Remove the 1kW test resistor and connect the battery to the output observing the polarity (important). Include the multitester in the circuit to measure the current as shown in Figure 5. Warning: make certain that all crocodile clips are kept apart or a very large current will flow from the battery. If those on the charger output touch, this current could ruin the meter.

With S2 set to Standby, there should be a reading of about 2A (as the IC heats up it may fall somewhat). When S2 is set to Cyclic, the current should be as previously decided. If it is too high, it may be reduced by increasing the value of R2 and vice-versa. If it is found that the current quickly falls (within a minute or so) to a very low value, this usually indicates that the heat produced by the IC is not being carried away effectively. The IC's internal over-temperature protection is then called into effect. Check that any paint under it has been scraped away completely and that the securing bolt is tight. In obstinate cases - perhaps where the surfaces are not perfectly flat - apply a smear of heat sink compound on the back of the IC However, in the prototype there were no problems.

In use, the maximum charge rate will not be maintained for long. Depending on the capacity of the battery and the state of charge to begin with, it will fall to around 1A as 13V is approached (cyclic mode). After that it will fall slowly to a constant trickle current which indicates full charge. In the prototype unit, the end-point currents were about 30mA and 10mA for Cyclic and Standby settings respectively. They could be adjusted by minute trimming of RV1 or RV2 as appropriate. It takes a long time to reach the end-point figures. In actual cyclic

PARTS LIST

Buylines

A good quality generously-rated transformer should be used.

RESISTORS

1/4W carbon film except R2 (see Table 1).

R1, 5	1k
R2	Rset - see Table 1 and manufacturer's data.
R3	4k3
R4	3k9
RV1, 2	470R sub-min vert. presets.

Additional 1kW resistor required for testing purposes - see text.

CAPACITORS

C1	2200mF 35V radial.
C2	220nF disc
C3	100nF disc

SEMICONDUCTORS

BR1	KBPC102 3A bridge rectifier (see Buy Lines)
IC1	L200CV regulator
D1	1N5400 or 1N5401
LED1	5mm panel mounting LED indicator.

MISCELLANEOUS

T1	Mains transformer with 18V (or twin 9V secondaries) rated at 2.78A (50VA) .
S1	Mains rocker switch
S2	2P 6W rotary switch - make-before-break action.

F11A 25mm ceramic mains fuse and panel fuse holder.

F22.5A 25mm quick-blow fuse and PCB fuseholder

PCB

Box for unit - minimum size 100 x 150 x 100 mm - see Buy Lines.

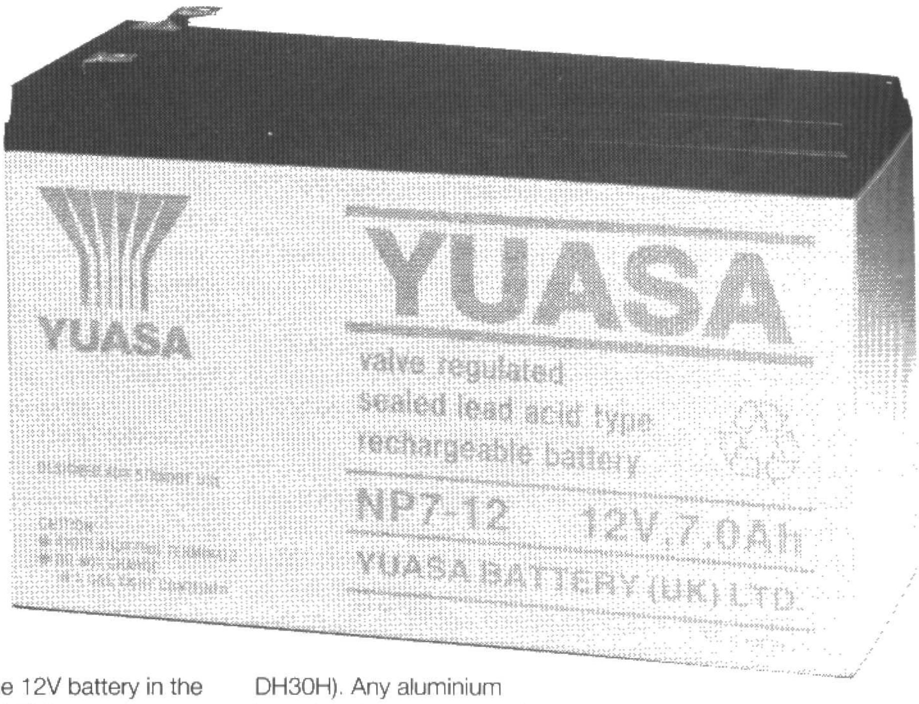
Knob to suit S2

Small crocodile clips

See also manufacturers' data for maximum cyclic charging current.

charging, the current is not being monitored so the end-point may not be reached - this does not matter. When charging a substantially discharged battery up to 8Ah, allow a charging time of 6 to 8 hours. For larger capacity batteries, increase the charging time in proportion. Experience will soon help to judge the correct timings. Give less time if the battery is only partially discharged and do not leave the battery connected to the charger for longer than is necessary (cyclic mode only).

Note that it is normal for the rear panel of the case to become hot especially at the beginning of the charging process when the unit is delivering a high current. If everything works correctly, plastic feet may be fitted to the base of the box and S2 labelled. The project may then be put into permanent service.



This project would be handy for charging the 12V battery in the mains-free workshop (Practically Speaking, ETI September, 1994). However, it may be used to charge any 12V lead-acid battery. It is particularly suitable for use with the small, popular 12V Yuasa type listed by several mail-order suppliers. You will need an accurate multitester - preferably a digital one - for checking the completed project and adjusting it for correct operation at the end of construction.

A good quality generasery- rated Transformer shood be used. This will ensure that it remains cool in operation. The one used in the prototype was obtained from Maplin (order code: DH30H). Any aluminium box of sufficient size may be used as the enclosure. The sloping-front chassis type used in the prototype (see photograph) was obtained from Maplin (order code XY41U). Suitable rotary switches are listed by most suppliers (e.g. Maplins FH43W). This must be capable of carrying 2A minimum and be of the make-before-break type.

Diode D1 (1N5400) may be replaced by type 1N5401 as listed by some suppliers. An alternative bridge rectifier in similar case style may be used but its current rating must be 2A minimum.

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MIDI EXPLAINED

Part 5 of Robert Penfold's tutorial series on MIDI systems takes a look at system messaging

Last month we considered some of the more basic system messages, the system real-time messages. This month we will continue with the subject of system messages, but will turn our attention to the system common messages. We will not consider the song position pointer message, as this is used in conjunction with the system real-time messages, and was described last month.

In Tune

The song select message is used to select the song (sequence) that will be commenced when a start message is received. This message is obviously only applicable to sequencers and instruments which have a built-in sequencer. Also, it only applies to sequencers that can store several sequences at once. It will be ignored unless the receiving device is set up to respond to MIDI real-time messages (i.e.unless it is set to use MIDI synchronisation). This message consists of a status byte followed by a single data byte (Fig.1). The song select message can therefore accommodate up to 128 different sequences, but most sequencers cannot handle anything approaching this number. As usual, it is a matter of carefully reading the equipment manuals to determine if this message is supported, and if so, the range of valid data values.

A tune request message may sound more like something you would send to Jimmy Young than to a synthesiser, but it's actually one of the lesser known (and little used) MIDI system messages. When the MIDI specification first came into being there were many analogue synthesisers in use, and many of these suffered from problems with tuning drift. In order to combat this problem, some synthesisers had an automatic retuning facility which could be used to correct any tuning drift at the press of a button. The tune request message is the MIDI equivalent to pressing this retuning button. Few analogue synthesisers having MIDI interfaces were ever produced, and this message is not really applicable to modern instruments with their largely digital circuits under crystal control. Consequently, this message is one which you are never likely to use, and may as well forget.

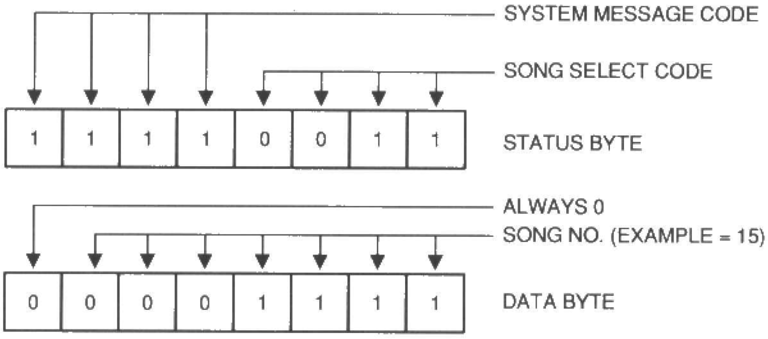


Fig.1. The method of coding used for the song select message

In Time

Conventional multi-track recording is basically a matter of building up a completed piece by recording it one track at a time using a multi-track tape recorder. The MIDI equivalent is to use a real-time sequencer to record a piece track-by-track, and then play it back into a MIDI system that has the wherewithal to reproduce every track correctly. The MIDI version of multi- track recording has definite advantages, and not the least of these is the ability to edit the recorded tracks in quite sophisticated ways. For example, most sequencers permit notes to be added, deleted, or corrected in pitch if a wrong note is played. Changes to the timing of notes is usually possible as well. On the other hand, MIDI is clearly only applicable to electronic sound sources, and only electronic sound sources that have a MIDI interface.

Is it possible to obtain the best of both worlds by using a mixture of MIDI sequencing and conventional multi-track tape recording? It is certainly possible to mix the two techniques and ,at a basic level, the sequencer is used to produce the backing tracks. These are then played back, and mixed into one or two audio channels which are recorded onto tape. The vocals or other non-electronic tracks are then added in the normal way. This is something less than ideal, and one problem is that once the backing tracks have been mixed and recorded, they cannot be edited, remixed, or altered in any way.

A more sophisticated way of handling things is to use a synchroniser, as in the example system of Fig.2. One track of the tape is recorded with some form of synchronisation signal, and the sequencer is synchronised to this signal via a suitable MIDI synchroniser. There are potential advantages to this system, and one of these is that it is possible to do some editing of the backing tracks recorded on the sequencer at virtually any stage of the proceedings. The backing tracks do not have to be recorded onto the multi-track tape, because the sequencer will always play in perfect synchronisation with the tape recorder. This leaves an extra tape track free, and avoids the slight loss of audio quality that would occur if the sequencer tracks were recorded.

It is only fair to point out that the set up shown in Fig.2 is just one example, and there are other ways of utilising synchronisers. Most, as in this instance, have a built-in merge facility that enables a keyboard and the synchroniser to drive the input of the sequencer. The exact way in which this facility operates varies from one synchroniser to another, and with this type of equipment you need to check the manual to determine the way in which it should be connected into the system.

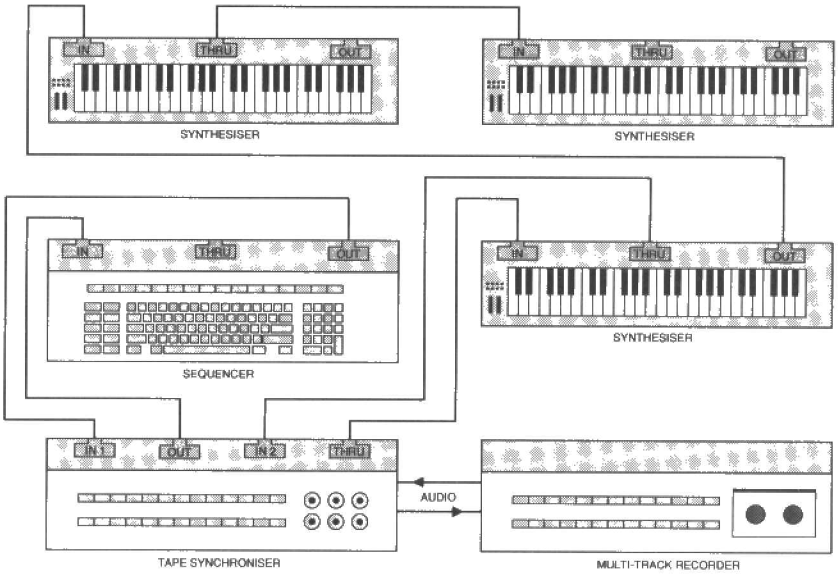


Fig.2. A typical setup using a tape - deck and a synchroniser

Originally the synchroniser had to provide timing signals to the sequencer in the form of MIDI clock messages, and other system real-time messages. In many cases this was perfectly satisfactory, but it is a method that sometimes requires a lot of processing by the synchroniser. In particular, the normal MIDI timing signals are far from ideal when using a SMPTE to MIDI synchroniser. SMPTE (Society Of Motion Picture Engineers) is a sophisticated method of time coding which is primarily intended for use in audio/visual systems, especially television and films. It does not simple provide a train of clock pulses, but instead operates on the basis of refined time coding in hours, minutes, seconds, frames, and sub-frames.

MIDI time coding (MTC) was not part of the original MIDI specification, but it was added in the "MIDI 1.0 Detailed Specification". It seems to have been added to enable MIDI systems to be used with SMPTE systems in a more sophisticated fashion than would otherwise be possible. The main MIDI MTC message is a system common type, and it is the quarter frame message. This is really eight different messages, with each one being used to provide part of the full time value. Therefore, a group of eight MTC messages is needed in order to send a complete time to the slaved sequencer.

Fig.3 helps to explain the way in which the two byte MTC message is coded. The status byte has the system message code (1111) as the most significant nibble, and the MTC code (0001) in the four least significant bits. This is followed by a data byte that only really uses the least significant nibble to carry the data value. The most significant bit is set to 0, in standard data byte fashion, and the other three bits are used to carry the MTC message number. In other words, these three bits indicate which type of MTC message it is, and these three bits are effectively part of an extended status byte. These are the eight MTC message types.

MTC Message No.	Value Carried In Data Nibble
0	Frame count, LS nibble
1	Frame count, MS nibble
2	Seconds count, LS nibble
3	Seconds count, MS nibble
4	Minutes count, LS nibble
5	Minutes count, MS nibble
6	Hours count, LS nibble
7	Hours count, MS nibble

There is rather more to MIDI time code than the MTC quarter frame message, and the general topic of MIDI synchronisation is a fairly involved one. A detailed discussion of this topic really goes beyond the scope of this article. Most MIDI users do not get involved with any form of tape synchronisation, and it is probably best to avoid this type of thing unless you genuinely have a need for such a facility. For most users the subject of MIDI/tape synchronisation is of purely academic importance.

Exclusivity

For MIDI to be successful it was clearly necessary for the hardware and software standards to be rigidly standardised. This was necessary to ensure proper compatibility between instruments from various manufacturers, and to avoid the incompatibility problems of the pre-MIDI era. The MIDI standard has stood the test of time, and in general there are no significant incompatibility problems between pieces of equipment from different equipment producers. The problem with such a rigidly defined standard is that it does not leave much scope, if any, for manufacturers to "do their own thing". If a manufacturer should come up with an astounding new feature they could find that there was no reasonably efficient way of implementing it via MIDI. The MIDI controls permit a certain amount of individualism, but are not versatile enough to handle all eventualities.

The MIDI designers realised that MIDI needed to be standardised rigidly enough to avoid incompatibility problems, but that it also needed to be versatile enough to handle any special features that equipment manufacturers might wish to implement. Their solution to the problem was system exclusive messages. The basic idea is to have a special class of message that permits the manufacturers to use any method of coding they like, to implement absolutely any feature they desire. The only proviso is that system exclusive messages should not be used to implement any ordinary features (pitch bending, control changes, etc.) that are catered for by the normal range of MIDI messages. This approach maintains a high degree of compatibility, but does not stifle new developments which MIDI might otherwise be unable to accommodate.

Fig.4 shows the method of coding used for system exclusive messages. The status byte has the system message code in its most significant nibble, and the system exclusive code (0000) in its least significant nibble. The first data byte carries the manufacturers identification (ID) code. In fact there are now so many manufacturers ID codes, that many now have three byte codes. The first byte is always 00 (hex), and the next two bytes then carry the manufacturers 14 bit ID code.

The manufacturers ID code is an essential part of the system. It is followed by an unlimited number of data bytes, and these can be coded in any way that the manufacturer sees fit. It is imperative that a unit should only respond to a system exclusive message that is intended for a device of that particular type. If a piece of MIDI equipment should respond to a system exclusive message intended for a different device, the effect of the message is unpredictable. It might be completely meaningless to the device receiving the message and could be ignored. On the other hand, it could completely scramble all the settings for every voice of the instrument!

In practice it is not usually good enough to simply rely on the manufacturers ID to prevent a MIDI device from responding to inappropriate system exclusive messages. Each manufacturer normally produces a wide range of MIDI units, including synthesisers of varying degrees of sophistication, samplers, and possibly MIDI accessories such as patch-bays and digital effects units. Clearly a sound sample will be of no relevance to a synthesiser, and a set of synthesiser sound generator settings will be irrelevant to a sound sampler. Even with something like two basically similar synthesisers, there can be differences in points of detail that make the sound generator settings for one instrument unusable with the other instrument.

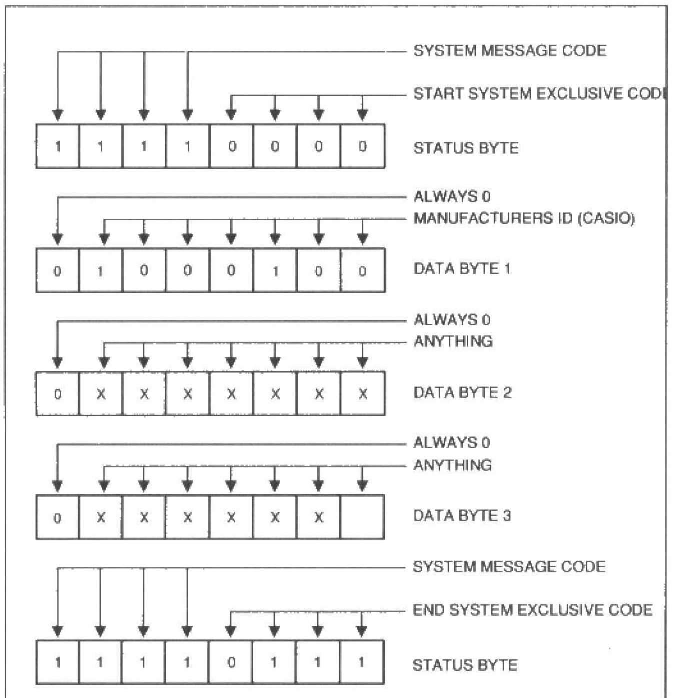


Fig.3. The MIDI time code quarter frame message is a two byte type

It is normally necessary for system exclusive messages to be machine-specific, rather than just specific to one particular manufacturer. The normal way of achieving this is for the manufacturers ID to be followed by a code number which indicates the particular model that the message is intended for (Roland D550, or whatever). However, everything after the manufacturers' ID falls outside the MIDI standard, and is coded in any manner the manufacturer desires. Therefore, if you wish to know about this, or any other aspect of system exclusive coding, it is necessary to refer to the appropriate manual. Incidentally, it is a requirement that manufacturers should make details of their system exclusive coding available to anyone that wants it. Also, third party manufacturers can make use of the coding in their products, such as dedicated controllers, or control software for popular computers.

TABLE 1

Manufacturer	ID Number
Sequential	01
Moog	04
Fender	08
Ensoniq	0F
Oberheim	1F
Apple Computers	11
Lowrey	6
Emu Systems	8
Siel	21
Hohner	24
Soundcraft	39
Roland	41
Korg	42
Yamaha	43
Casio	44
Akai	47
Sony	4C
TEAC	4E
Fostex	51
Alesis	00 00 0E
Opcode	00 00 16

The end of a system exclusive message is marked using a single byte message. This has the system message code as its most significant nibble, and the end system exclusive code (0111) as its least significant nibble. There is no limit to the number of data bytes that can be used between the manufacturers ID and the end system exclusive message. In theory it is quite in order to use a million or more data bytes per message if desired. In practice it is unusual for large amounts of data to be handled by a single system exclusive message. The more usual method is to use hundreds or even thousands of messages, with each one carrying perhaps a few hundred bytes of data. This normally operates in conjunction with a system of error checking, and possibly software handshaking as well.

System exclusive messages are potentially very useful, but they have a reputation for being problematic. As pointed out previously, most system exclusive messages are exclusive to one particular device, rather than to one particular manufacturer. If you have several MIDI units from one manufacturer there is no guarantee that these units will be able to "talk" to each other via system exclusive messages. If every unit in your MIDI system comes from a different manufacturer, it is highly unlikely that you will be able to make much use of system exclusive messages.

Bear in mind that the default state for most MIDI units is to ignore system exclusive messages. This is apparently to reduce the risk of accidentally altering all the sound generator settings, or doing something equally dire. In order to send or receive system exclusive messages it is therefore necessary to switch on this facility.

In some cases you have to provide a two-way link between the devices by cross coupling the MIDI IN and OUT sockets, even if data is only being sent in one direction. This is due to the fact that the exchange of system exclusive messages

sometimes relies on he sending device transmitting an initial message, followed by the receiving unit sending an acknowledgement message to indicate that it is ready to receive the data. The sending device then sends the data. Without a two way coupling the sending device never receives the acknowledgement message, and simply hangs-up.

Many sequencers are able to record and play back system exclusive messages, but there can be problems if this two-way dialogue is required. It is important to realise that system exclusive messages are not meant to be sent along with performance data. The intention is that they should be used to set up an instrument in the desired fashion prior to a performance,

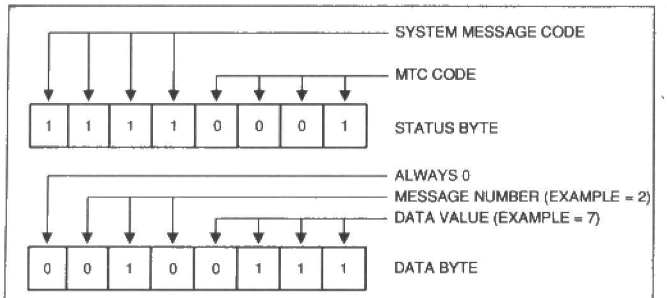


Fig.4. Coding for a system exclusive message
There can be any number of data bytes

rather than making changes mid-performance. It is not impossible to use system exclusive messages mid-sequence, but it has to be borne in mind that exchanging large amounts of data via MIDI can take quite a long time. Exchanging large amounts of data via MIDI can take several minutes. Also, it might take an instrument a significant time to respond to long system exclusive messages. Mixing system exclusive messages with performance data could clearly produce some very long and totally unacceptable gaps in a piece. Using a few short system exclusive messages would presumably not significantly affect the timing of a sequence. The only way determine exactly what you can and can not get away with is to make some practical tests.

Table 1 gives the ID numbers for some well known manufacturers. The numbers are in hexadecimal incidentally.

Exclusive To Everyone

The idea of system exclusive messages was to enable manufacturers to implement their own special features via MIDI. However, it was inevitable that at least one or two features would be implemented via this route by numerous manufacturers. This leads to a position where there are a number of instruments on the market which implement much the same feature via MIDI, but in a totally incompatible way due to the use of system exclusive messages. This is clearly undesirable, and goes against the general spirit of MIDI.

In an attempt to overcome this potential incompatibility, so-called universal system exclusive messages were introduced. This may sound like a contradiction in terms, which it is, but the basic idea is a sound one. Where several manufacturers are implementing much the same "special" feature via MIDI, a standard system exclusive message to handle that task is introduced. Manufacturers should then adopt this universal message, rather than sticking to their own system exclusive method. In reality, the MIDI specification is not exactly brimming over with examples of universal system exclusive messages. The only message of this type in general use is the sample dump standard, which is used for exchanging sound samples. All sound samples are basically just a series of digitised values, so they are obvious candidates for a standard method of exchange.

In practice there can be a few problems when using the sample dump standard. The most obvious one is that this "standard" has not been adopted by all manufacturers of sound samplers, and many samplers were produced before the sample dump standard was agreed. It is a matter of checking the equipment manuals to determine whether or not a particular sampler uses this standard (or perhaps a system very closely based on it). There is a major drawback with the sample dump standard, which is simply the time it takes to exchange large samples. MIDI can only handle about 3k per second, and sound samples can contain a megabyte or more of data. At best it takes about six minutes to transfer one megabyte via MIDI, and transferring large samples could therefore take 15 minutes or more. Of course, this is a limitation imposed by MIDI itself, and is not due to a fault in the sample dump standard. Being practical about it, if there is an alternative means of transferring large amounts of data (e.g. via a floppy disk), this will usually be more satisfactory than using MIDI.

The sample dump standard can be used with or without software handshaking. Either way, data is sent in packets of 127 bytes, of which 120 bytes are the actual sound sample data. The first message is always a 21 byte dump header message, which is coded in this manner:-

```
System exclusive header byte (F0 hex)
Sample dump ID number (7E hex)
Channel number
Dump header code (01 hex)
Sample number (two bytes, LSB first)
Sample format (number of bits, from 8 to 28)
Sample period in nano seconds (three bytes,
LSB first)
Sample length in words (three bytes, LSB
first)
Sustain loop starting point (three bytes,
LSB first)
Sustain loop end point (three bytes, LSB
first)
Loop type (00 = forward, 01 =
backward/forward)
End system exclusive message (F7 hex)
```

Although the sample dump standard can accommodate samples having resolutions of between 8 and 28 bits, many samplers will only accept samples over a much narrower range of resolutions (typically 12 to 16 bits). As always, it is a matter of carefully reading MIDI implementation charts and the MIDI manuals in order to determine the limits of your particular instruments. The packets of data use this format:-

```
System exclusive header byte (F0 hex)
Sample dump ID number (7E hex)
Channel number
Data packet code (02 hex)
Running packet count
120 bytes of data
Checksum (XOR of previous 124 bytes)
End system exclusive message (F7 hex)
```

With only seven bits of data per byte it obviously takes two, three, or four data bytes per sample word. The data is left justified, and unused bits are filled with zeros.

There are four handshake signals, and these are only sent by the receiving device. The main one is "ACK", which is used to indicate that the last packet was received correctly, and the next packet should be sent "NACK" is used when a packet of data has not been received correctly, and the previous packet must be sent again. The "Wait" message is used to provide a hold-off while the receiving devices processes the data. An "ACK" message is used when the data has been processed and the next packet is required. The "Cancel" message is used to abort a sample dump. A sample dump can be initiated from the front panel controls of a sampler, or via MIDI and a "Dump Request" message.

In next month's concluding article we will consider the subject of General MIDI, and we will also take a look at the hardware side of MIDI.

MAGNETISM AND MAGNETOMETERS

Magnetism is a subtle and mysterious force that influences a lot of things around us. Keith Garwell concludes his practical exploration of how to measure minute changes in a magnetic field by commissioning the Fluxgate Magnetometer described last month.

Having built the fluxgate magnetometer described in the last two issues, it is now time to test and calibrate it.

For this purpose we need a high resistance (not less than 5M) voltmeter, which will read 0-12V DC and 0-4 AC rms. If AC rms is not available, then peak AC will do and I imagine practically any digital voltmeter will meet these requirements.

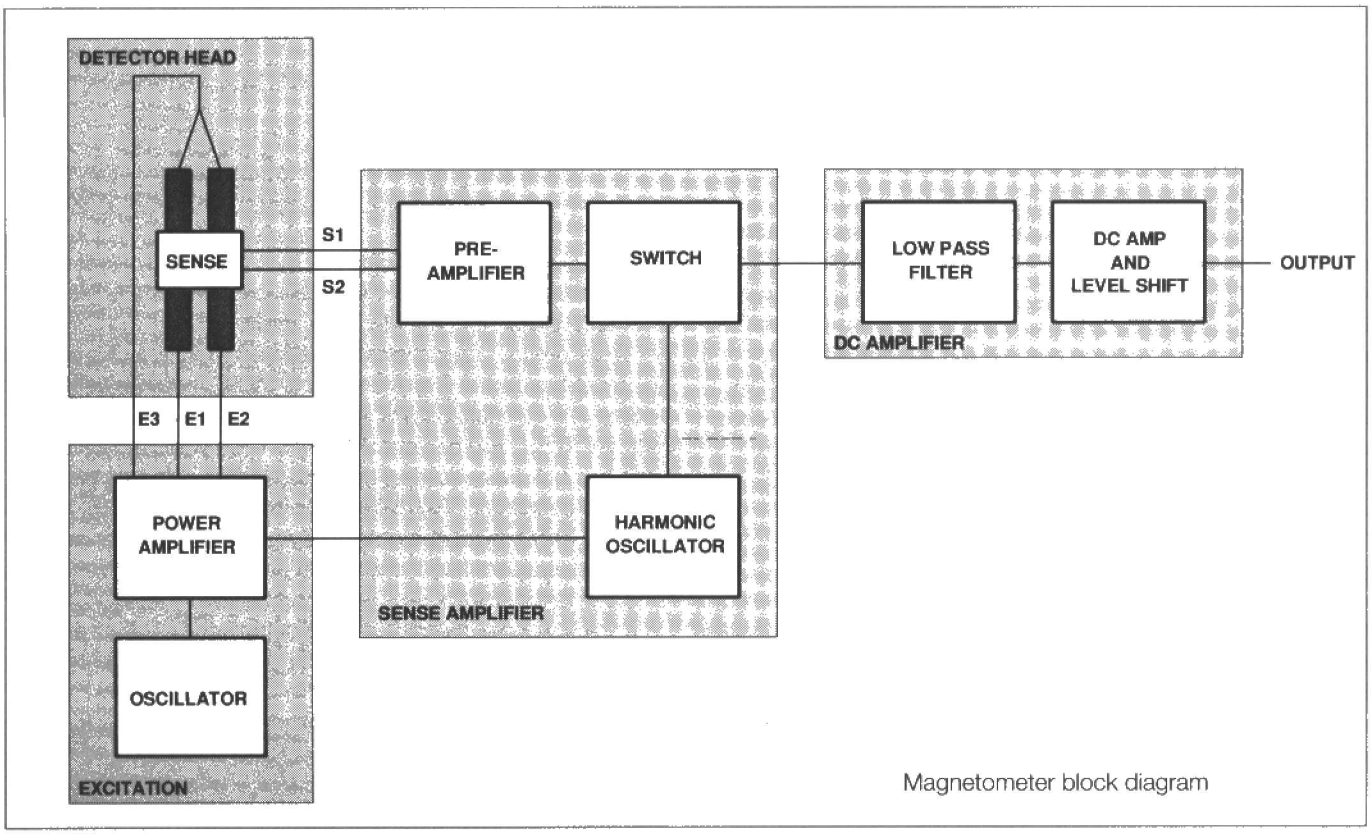
You need to know the orientation and a simple compass will do the trick, the variety used by the orientiers being ideal. A piece of card marked out as in Figure 18 will be helpful and should be set by means of the compass to point to magnetic East.

A scope or any other instrument which will indicate frequency, including speaker and amplifier, will be helpful to reassure you that the second harmonic oscillator is correct, but is not essential.

The 12V supply must be regulated. I'll say a few words about portable working at the end, but for getting it working in the first instance it's worth lashing up a mains PS. A half amp 12V tranny with bridge rectifier and half amp regulator will do fine (the magnetometer takes about 150mA all told, about 110 - 120 mA of which is taken by the exciter). There should be 2.2µF across the output of the regulator. Fit one to the input to the electronics if you are not sure; after all it doesn't cost much.

The Exciter

Set up the exciter board first, ie don't connect the sense amp board at all. Make the usual basic checks - no shorts across the



Magnetometer block diagram

DC input and so on. Then connect the head to E1 and E2, leave E3 disconnected at the moment. Power it up and check the rms voltage across E1, E2. Adjust R11 until there is exactly 2.00 AC rms present. If using a peak meter thats 2.8 VDC peak or 5.6 p-p. If you are using a scope the waveform here should be a rather splendid sine curve!

The Sense Amp

This magnetometer is very sensitive and the pitfalls in setting it up are legion. If you get any oddball readings while trying to set it up then look round for the odd bit of ferrous metal. My first problem was that the table I was using had steel hinges so I moved the head to a nearby window-sill which had nails in it. This was resolved by setting it up on top of a dictionary which is very thick. Then I realised that there was a steel buckle on my trouser belt and so it goes on. Finally, the moving coil meter was upsetting it on account of its internal magnet and it was nearly a metre away from the head. As I discovered when I turned the meter round a bit so that I could see it better! Screwdrivers are invariably magnetised though this is fairly obvious as things start to change directly one picks it up to adjust one of the pots. As a generalisation the head needs to be at least a metre from any iron or steel - more if it's likely to be magnetised.

The actual setting up procedure can be a bit of a bind as it's very easy to go round in a loop and at one point you do! Definitely an exercise for morning - or whatever time of day you're best at. I exaggerate of course, but it is a wise move to write out the sequence and tick it off as you do it. Here it is -

The 12v and 0v are connected and the exciter is running. Leave it for five or ten minutes to settle down.

The gain (R2) if variable should be set to maximum, ie.R2=1M.

The head balance E3 is disconnected.The sync input from E2 is disconnected.The sense winding S1, S2 is disconnected. (Switched off). A moving coil voltmeter suitable for measuring 0 to 10 volts is connected between the output and 0v.

Adjust the output control to give 4v on the meter.

Connect the sense winding (switch it on). Orientate the head easterly.

Adjust the frequency control to zero beat.This is perhaps best done by starting from the lowest frequency (fully anticlockwise) and slowly increase frequency by the 18t pot until the meter starts to swing back and forth. Continuing the meter should become stationary (or only move slowly) and then start swinging back and forth again. Now turn in the opposite direction until the meter is stationary once more and reading approximatly 4v. If this doesn't seem to work check the 555 is oscillating by checking the voltage at pin 3 this should be approximately 6v. If you have the means to check frequency measure the exciter frequency and then check the 555 can be adjusted to twice this. It may be necessary to change the value of R20. Increase it to reduce the frequency and vice versa. Without any frequency measurement it will have to be a cut and try exercise.

Connect the sync input. Connect (switch on) the sense input.

If the reading goes off the scale reorient the head until it comes back on.

Then alternately adjust the sync pot and reorient the head until the reading is 4v with the head pointing due east.

Alternately reverse the sense conections and adjust the sync pot until the reading remains the same when the sense connections are reversed. This may not be 4v any longer.

Connect the head balance. Align the head due East.

Adjust the head balance until the output returns to 4v.

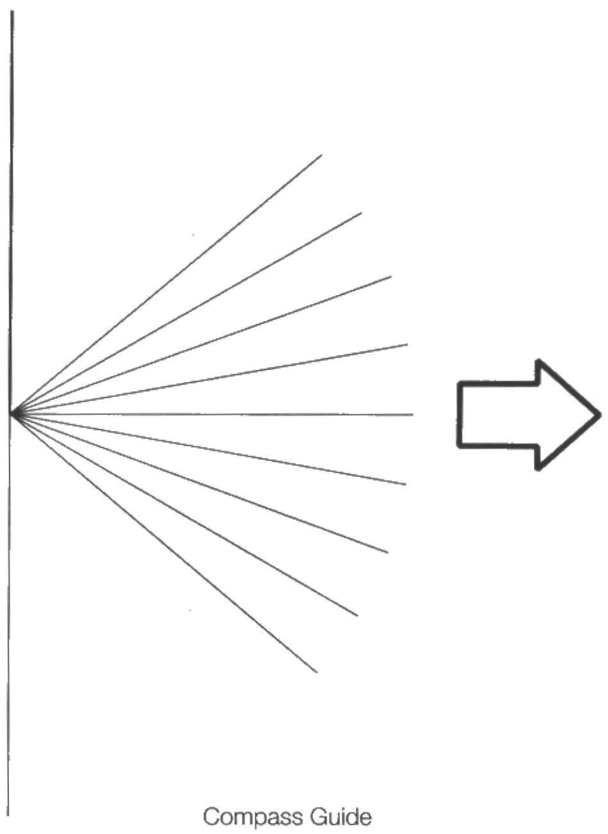
Turn the head on the card until the meter reads 3v and mark its position.Turn the head until the meter reads 5v.

Check that the two positions are either side of the East line and make roughly the same angle with it.

If it doesn't matter that North/South variations are not identical then that's the end of the exercise.

If you want the symmetry as close as possible then repeat the sense amp / head balance adjustments to see if it can be improved. Beware of anything which might bend the earth's field near your work space. As the two rods in the head are a finite distance apart anything magnetised and at right angles to the head orientation will spoil the symmetry.

Finally make good any connections used for setting up and the magnetometer is ready for use.



Compass Guide

IN CONCLUSION

Sensitivity

The limiting values of the output should be taken as 0 and 8 volts to play absolutely safe. Zero is perfectly OK for the CA3140 but the output cannot rise nearer than about 2.2 volts to the positive rail (12v) giving a theoretical maximum of 9.8. If it really would be convenient to go from 0 to 10 theres a fairly simple arrangement which requires a transistor adding to the output of the CA3140. See OP-AMP Circuits Manual by R. M. Marston in your local library.

The response of the head follows a sine law where zero degrees is due East (magnetic East that is).

With the head aligned due East, 7 degrees of movement either side gives an output of approximately 3 volts. This is with the configuration given in the schematics and adjusted according to the commissioning procedure given.

We know that the earth's horizontal field is 18uT. The sine of

7 degrees is 0.122. Pointing due North the sine would be 1. Therefore the sensitivity pointing North would be 18 x 0.123 = 2.2uT for 3 volts of output. Or, to put it more tidily 0.74uT per volt.

If the sense input is switched off and the meter reading set to zero by means of the output level adjust pot, then (with the sense switched on again of course) the maximum level which could be read (ie equal to 8v) would be 5.9 uT. This assumes that pointing the head North increases the reading, if it doesn't reverse the sense connections.

Therefore, to measure the earth's field either horizontal or vertical components the sensitivity would have to be reduced by a factor of 10. Given the correct resistors the scale could be made even more convenient. Like 10uT per volt.

Unfortunately it's not likely to be so perfectly linear that changing resistors according to the arithmetic would give spot-on accuracy. A little bit of trial and error may be necessary. For instance, reduce the gain by 10 then see what the reading is like and adjust the gain accordingly.

This is all a case of trusting the earth's field to be known accurately at the location where this is all going on. If it isn't, then friend Helmholtz comes to the rescue.

If two circular and identical coils of wire are arranged such that they are separated by a distance equal to their radius and the same current passes through each, then a fairly uniform field exists between them. The strength of this field is equal to -

`0.72 x N x I x uo /R`

Where -

N is the number of turns on each coil; R is the radius of each coil (and also their seperation); I is the current in amperes; uo is the permitivity of free space and is 4 x pie x 10^-7. The field is in Teslas.

This gives a fairly simple way of calibrating the magnetometer. Assuming that the head is about 5 inches long (120mms) then the radius should be rather greater than this, say 150mms. That is R in the above formula will be 0.15.

For further details see any A Level Physics book.

Portability

There are two problems, current consumption and regulation. Since all batteries change their terminal voltage as they discharge the battery supply would have to be regulated. This can easily be done using a half amp regulator; unfortunately 100mA is not enough. The regulator must have "headroom" ie. the supplied voltage must be higher than the required output by about 2.5 volts.

This suggests a PP1 plus a PP9 to give 15v, followed by the regulator (and don't forget the 2.2uF capacitor). According to my estimation this would run the magnetometer for about 20 to 25 hours and cost about £5. I should say that I'm not very sure of the current capability of such batteries, 150mA sounds a lot and I would want to see the spec for the batteries before I parted with my money.

Even if they would stand the strain, if the magnetometer is to be used much primary batteries as above seem like an expensive option. Again doing a bit of estimating secondary cells would be a better bet. For instance a sealed lead acid battery at 12v and 2.8 Ah costs less than £20. This leaves the problem of regulation which can be overcome with a suitable DC to DC converter. Such a converter (eg. L78S40 Maplin) would cost about £2 for the bits plus a box to put it in.

Curiously enough such a device also needs headroom but the other way round; the input must be less than the output, but 1v is sufficient. This odd volt can be dropped across a resistor connected in series with the input. This assumes the battery will not be on charge whilst in use. A freshly charged battery will need a few minutes to settle.

Assuming an efficiency of arround 70% and the magnetometer current to be 150mA (mine takes 124mA) a charge would run the magnetometer continuously for 13 hours. Incidentally, if it is getting this sort of use, don't switch it off to save ten minutes - it really takes that sort of time to settle.

An alternative battery would be nickel cadmium cells. Nine of them would give 10.8v which would run the converter without the necessity for the input dropping resistor and 600mAH (AA cells) would cost about the same as the acid battery and run for about 3 hours.

Metering

So far I have assumed that a moving coil meter will be used as the indicator. Such a meter need not be madly sensitive as the CA3140 can deliver several milliamps.

One must remember that a moving coil instrument averages out the current whereas digital devices will take a snapshot of the voltage. Now there is a far amount of "rubbish" in the output which requires the presence of the low pass filter R7 and C3 in Fig 14. However, the MC meter averages this out and comes up with the right answer. A digital meter, however, will be upset because it is not averaging.

If a digital meter is used there are a number of possibilities. The simplest is to make the filter even lower pass by increasing C3 by a factor of 10 or more. It is also possible to add a capacitor in parallel with R8 to further reduce the frequency response or add a simple RC filter between the ouput and the meter.

Another possibility is to make the digital device do the averaging. If the reading is done by any sort of computer-driven ADC, then insert the averaging into the computer program. Or to be really with it don't bother with the switching circuit or second harmonic oscillator or output stage. Just use the sense amp, digitise its output and do the arithmetic by software! In effect, do the switching and averaging mathematicaly.

Finally

One or two thoughts for the day, but primarily to just reiterate the way in which the instrument behaves.

Remember that it is most sensitive when it is pointing to, ie in line with, the magnetic field. Under this condition it will only be sensitive to change in field strength not direction. Correspondingly when it is at right angles to the field it will be most sensitive to changes in direction. If both changes in direction and changes in intensity are to be detected then it is best if set to an intermediate value, perhaps 45 degrees to the field.

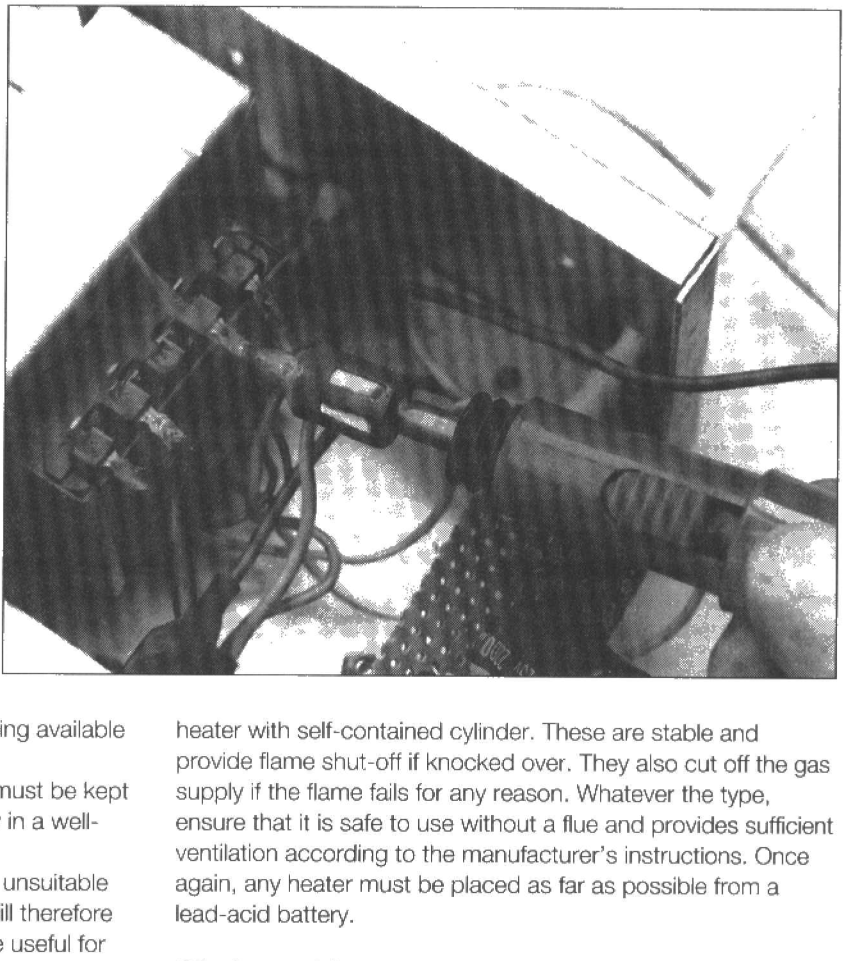
This can be easily illustrated. Suppose the angle varies from in line by one degree ie. from 90 to 89 degrees. Sine 90 is 1, sine 89 is 0.9998 a change of 0.0002. However, at right angles the variation is from 0 to 1 degree. Sine 0 we know is 0, whilst sine 1 is 0.01745 giving a change of 0.9825 or nearly 5000 times the in line figure.

Lastly, in any work associated with the earth's field it is still common practice to refer to a horizontal component and a vertical one. However, a very small change in attitude of the head will give a false reading and so, particularly in portable work, a spirit level would be useful. How about one of the small circular ones stuck to the case of the detector?

Practically Speaking

by Terry Balbirnie

Low - Voltage Equipment



Last month we looked at the setting-up of mains-free workshops using a 12V battery as a power supply. Although the availability of suitable low-voltage equipment is limited, it is perfectly possible to operate a workshop in this way. This month we shall look at the equipment available and show how to choose a battery with the correct capacity for the job.

Soldering Iron

You will need to choose between a gas soldering iron and a 12V one. The Antex MLXS 12V Soldering Iron Kit contains an XS 25W soldering iron, stand and length of solder. The Antex CS (17W) and XS are also available separately in 12V options. The same company also produce the GasCut butane soldering iron - this uses lighter fuel and will run for up to 55 minutes on one charge. Light Soldering Developments produce the Litesold LC18 (18W) and LA12 (12W0 soldering irons. These also make a good choice being available in 12V versions.

Note that if a gas-type soldering iron is used, it must be kept well away from any lead-acid battery and used only in a well-ventilated area.

Of course, the battery supply used direct will be unsuitable for circuits requiring an input of only 6 or 9V. You will therefore need some type of variable-voltage unit. This will be useful for testing projects and will be much cheaper to use than dry batteries. Such a power supply providing a continuous output from 3V to 9V with current-limiting will be described as a constructional article in a future issue.

Light Work

General lighting is best provided by fluorescent fittings. These are much more efficient than filament lamps provide virtually shadow-free illumination which promotes safe working. The caravan type will be found very suitable. Some are available with single or dual 8W tubes, others with a single 13W tube. Labcraft produce a range of suitable lights. One of these, the Tri-Lite, contains three 8W tubes (see illustration). This may be operated with either one, two or three tubes in position to suit the purpose. The same company also produce reading lights fitted with 10W filament bulbs which may be used as spotlights to direct light on close work. These lights are all available from caravan dealers.

In cold weather, it will be necessary to use a portable heater and the most convenient type uses propane or butane gas. The 12V battery, of course, has insufficient capacity to provide heating. The type of free-standing camping fire which uses the gas cylinder itself as the base with the burner attached to the top is not safe for workshop use. Use a small domestic-type heater with self-contained cylinder. These are stable and provide flame shut-off if knocked over. They also cut off the gas supply if the flame fails for any reason. Whatever the type, ensure that it is safe to use without a flue and provides sufficient ventilation according to the manufacturer's instructions. Once again, any heater must be placed as far as possible from a lead-acid battery.

Choice of battery

Last month we mentioned the wisdom of using a proper leisure battery as a supply even though these are more expensive than the standard car-type. To select the capacity of the battery, you will need to use the "amphour" (Ah) figure stated for it (the Exide Portapower range comprises 60, 75 and 90Ah versions). The capacity figure is the current which the battery can supply (in amps) multiplied by the number of hours over which it can maintain it. In fact, the amp-hour capacity falls with increasing current and it is usual to quote it at the 20 hour rate (that is, the battery continuously discharged over a period of 20 hours). However, for an approximate calculation, this may be ignored. A 12V appliance consumes 12W for each amp of current drawn.

For example, three 8W flourscent tubes (24W) will consume 2A. A small spotlight (10W) a little less than 1A. A 25W soldering iron a little over 2A. This gives a total of about 5A so a 60Ahr battery could operate these continuously for about 12 hours before the need to re-charge. However, it would be much better to limit the period of use to 8 hours or so to prevent the battery being discharged excessively. It is always wise to select a higher capacity battery than is actually needed so that it will run down as little as possible during use. This will maximise its life.

Next month we shall look at one of the most important workshop matters - the art of soldering!

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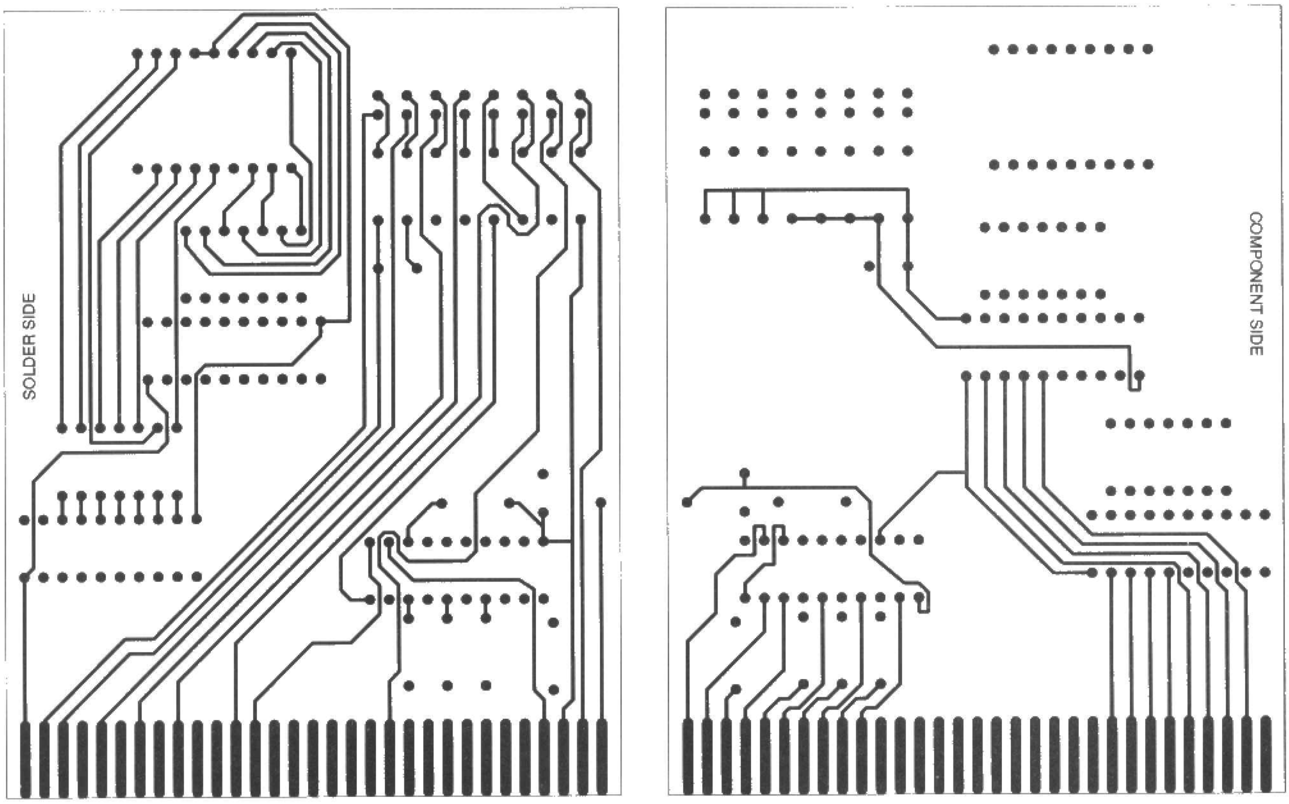
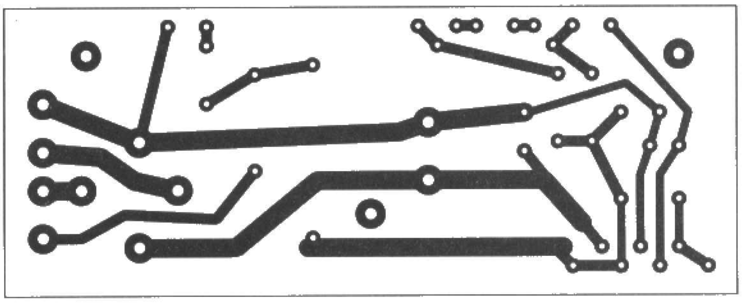
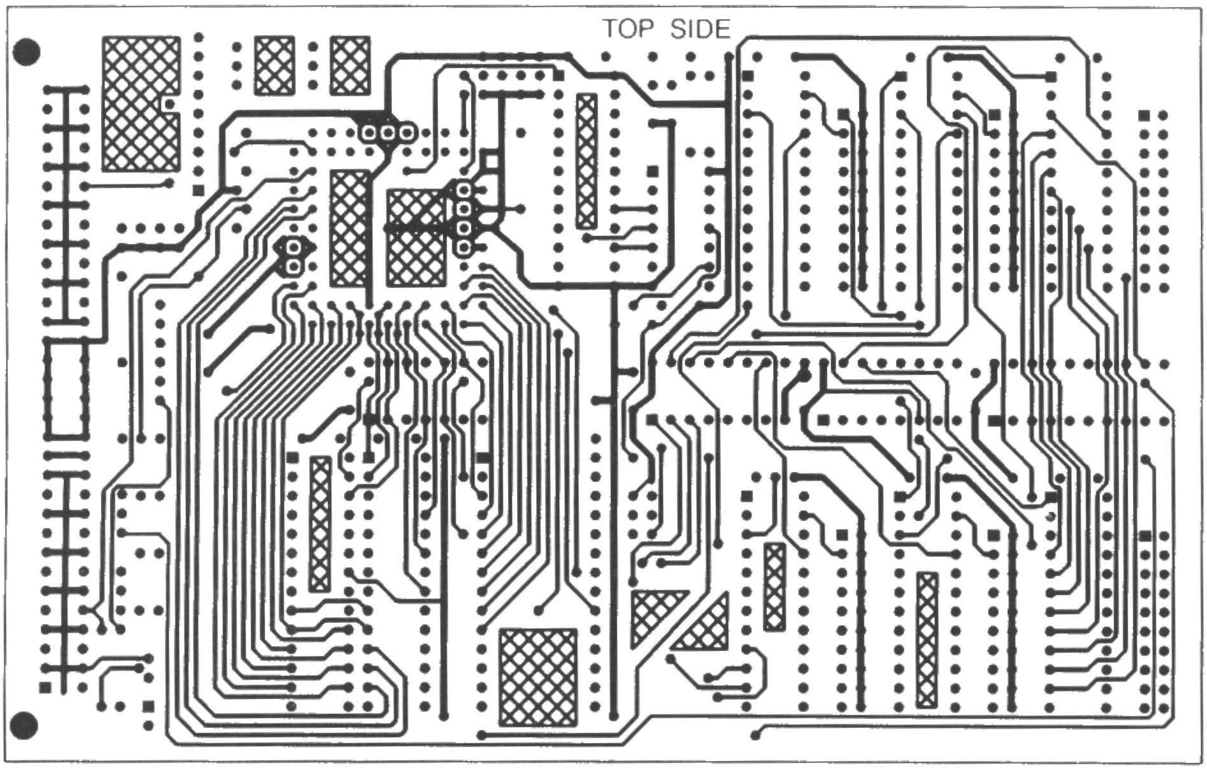
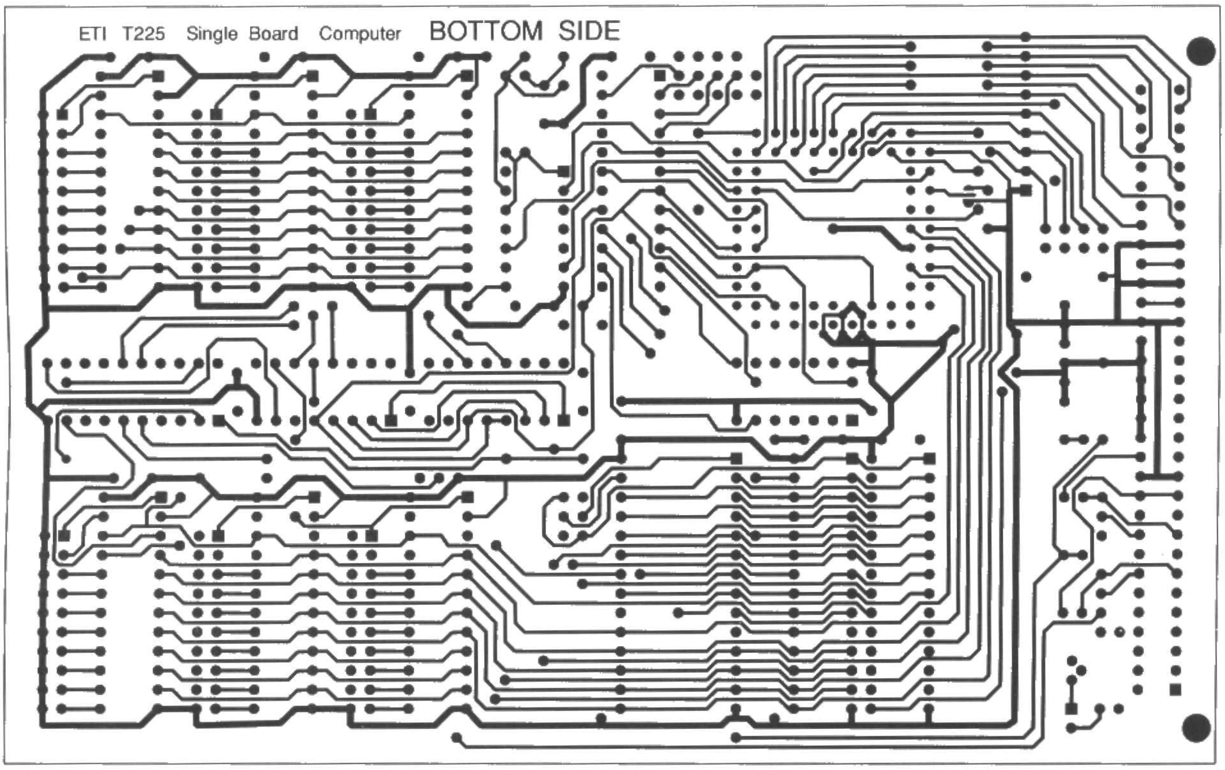


Power on self test card



Battery charger





Transputer based single board computer

Forum

It has recently been calculated, by an American economist, that the value of all the computer data flowing across the telecommunications networks of the world is, at any one instant, greater than the value of all the physical goods in transit at the same time. Of course the value of information passing between computers is extremely difficult to quantify, but this comparison does raise some interesting points.

It shows, of course, that information is now big business. It also shows that just as manufacturing requires an investment in transport infrastructure, roads, railways, ships, airlines etc. in order to operate efficiently, so businesses based upon information will require an infrastructure of high capacity, reliable, and cheap telecommunications.

Information based business is booming, you only have to look at the business activities of the latest generation of super-rich entrepreneurs, people like Bill Gates of Microsoft, or Larry Ellison of Oracle. In the past, billionaires were made in railways, shipping, oil, and mines; today they are created by the information industry.

In this issue of ETI we take a brief look at just a handful of the countless different technologies and potential applications for such an information infrastructure, what Vice President Al Gore called 'the information superhighway'. If information-based business is to expand, then it is vitally important that the necessary investment is made in order to build this infrastructure. Without it, information businesses are in the same position as manufacturers without roads, railways and ports.

If the UK is to remain an advanced nation then it is vitally important that the investment in this infrastructure is made, and made as soon as possible. Delaying the construction of such a network will just hand most of the potential benefits to businesses in those countries which do seize this enormous opportunity and make the appropriate investment.

We have to ask, therefore, whether it is right for the government to prevent British Telecom from entering the video on demand business and thereby eliminating a large chunk of the potential profit from an investment in fibre optic transmission networks. The government's stated reason is to protect the cable TV companies from competition by a technologically and financially extremely powerful company.

Looked at from some angles, the government's action has merit, though it is rather strange coming from a government that passionately believes in the freedom of market forces. But, for the country, this is probably an economic disaster since it is effectively preventing an investment in the type of information infrastructure which is essential for our future prosperity.

We are facing a great challenge, we are at the beginning of the information revolution. In the early part of the last century, Britain gained an enormous industrial advantage by being the first country to have a comprehensive rail network and by having the world's largest merchant fleet. Thanks to these, trade and manufacturing flourished, and prosperity followed.

The information superhighway is today's equivalent. Let us not miss the opportunity for employment and prosperity that its construction will undoubtedly bring. The government should stop interfering in its development and let it be built by whichever company, or companies, have the technological and financial capability, and will, to do so.

Next.Month...

The main feature article in the November issue of ETI will be a look at the 'Brains of men and machines' - the question of whether machine intelligence is really a possibility. On the practical side, we will be starting a new major project to build a parametric equaliser, a must for all audio fans. And of course we will also be continuing the Transputer and POST card projects.

For those of you wanting to use your PC to input and output data to external circuitry we have a project which will expand the capability of your parallel port, while for electronic music fans there is a Wah Wah Pedal design by Robert Penfold as well as the last in his MIDI tutorial series. There is also an interesting little project which allows one to control multiple devices from a single switch.

Next month there will be another free cover disk on the cover of ETI; this will contain some extra libraries for Quickroute Lite and a very useful DC circuits simulation programme. Make sure you do not miss getting your copy by ordering it from your newsagents today.

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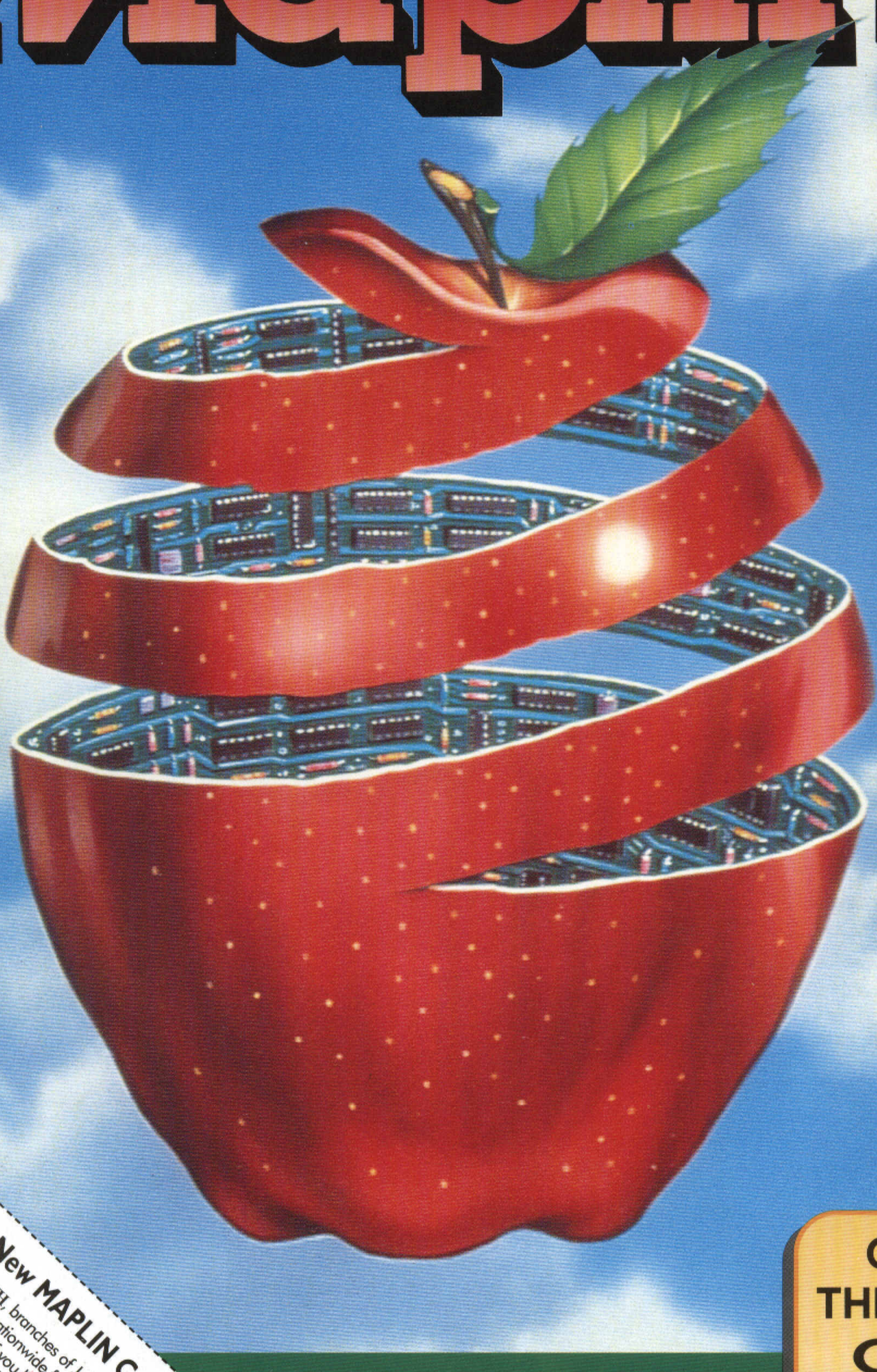

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